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FOR THE COMMANDER

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A CLOUD CLIMATOLOGY FOR THE NORTH PACIFIC AREA CENTERED AT SHEMYA, ALASKA

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ABSTRACT

A cloud climatology data set for the North Pacific area is presented based on monthly statistics of mean cloud percent and frequency of occurrence of cloud amount for 18 grid-point locations within approximately 1000 km of Shemya, Alaska. The cloud statistics are derived from the Air Force 3D-Nephanalysis Global Cloud Archive (3D-NEPH Model) for the period 1977 to 1983. These cloud statistics, together with atmospheric temperature profiles derived from the Air Force Summarized Analysis Data Set, are used to determine estimates of cloud top heights and temperatures for representative months at the various locations.

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1. INTRODUCTION AND SUMMARY

This report presents a cloud climatology for the North Pacific area, centered at Shemya, Alaska. The cloud climatology is based on the Air Force 3D-Nephanalysis Global Cloud Archive, a five-year data base derived from satellite observations. Atmospheric temperature and moisture profiles from the Air Force Summarized Analysis Data Set are used to derive estimates of cloud top heights and temperatures. The understanding of LWIR earthshine is a key element for data analysis of Soviet missile systems re-entering into the Kamchatka Peninsula region. In this report, a region of 1000 km in radius centered around Shemya, Alaska, is chosen for the climatology study. In order to establish upwelling LWIR earthshine, it is necessary to obtain temperature and moisture profiles, total cloud coverage and cloud top height/temperature.

The cloud statistics indicate an overall high percentage of cloud cover in the North Pacific area, particularly at the lower cloud layers. Considerably smaller percentages of high cloud are indicated. The statistics show some geographic differences, with northernmost locations tending to have less cloud and locations near Kamchatka and along the Aleutian island chain having greater average cloud amounts. Seasonal variations in cloud cover are small.

Although it is difficult to derive overall estimates of cloud top heights and temperatures, the upper limit of high cirrus in winter is indicated to be at about the 9,000- to 10,000-m level with a cloud top temperature of -40° to -50°C; in summer, the cirrus level can be higher, approaching the 16,000-m level, with a cloud top temperature of -50° to 60°C. The highest cloud layer with amounts consistently greater than 30 percent, and in some locations near 50 percent, is approximately at the 3000- to 5500-m level with cloud top temperatures of -25° to -30°C in winter and -10° to -15°C in summer.

The sources of the climatological data are discussed in Section 2, including a description of the Air Force 3D-Nephanalysis Global Cloud Archive; processing of the data and a discussion of other relevant data sets are also discussed in this section. The cloud climatology is discussed in Section 3, the atmospheric profile data in Section 4, and the estimation of cloud top heights and temperatures in Section 5. The Mean Cloud Amount Statistics, Percent Frequency of Cloud Amount Statistics, and Atmospheric Temperature and Moisture Statistics are presented in Appendices A, B and C, respectively.

2. SOURCE OF DATA

The source of data for the Shemya/North Pacific cloud climatology is the Air Force 3D-Nephanalysis Global Cloud Archive, which is an archive of cloud data derived primarily from satellite observations with some input from other Air Force data sets. The archive, referred to as the Air Force 3D-NEPH model, is described in Section 2.1. The 3D-NEPH data period used for the Shemya cloud climatology is 1977 to 1983.

In addition to the cloud data, atmospheric profiles of temperature and moisture were also acquired. These profiles are from the Air Force Summarized Analysis Data Set, an archive derived from global upper air observations. The profile data set, which is for the period 1977 to 1982, is described in Section 2.2.

Both the collected cloud amount and profile data sets consist of mean monthly values for 36 grid-point locations within approximately 1600 km of Shemya (52.3°N, 174.3°E). Data from 18 locations within approximately 1000 km of Shemya were used to derive the cloud climatology results given in this report. The geographic area within 1000 km of Shemya extends from about 45° to 65°N and from 165°W westward to 155°E. A map of the grid-point locations is shown in Figure 2-1, and a listing of the latitude-longitude coordinates of the locations is given in Table 2-1. This geographic area in the North Pacific includes the Kamchatka Peninsula to the west, a portion of easternmost Siberia to the north, and almost the entire Bering Sea and Aleutian island chain to the north and east of Shemya; the area to the south within 1000 km is entirely ocean.

2.1 CLOUD DATA SET

2.1.1 Description of 3D-NEPH Model

The Air Force 3D-Nephanalysis Global Cloud Archive was originally referred to as the 3D-NEPH model, but since late 1983 it has been called the RT-NEPH model. The model is described in *The AFGWC Automated Cloud Analysis Model* [4]. A one-year global total cloud amount climatology compiled from the 1979 3D-Nephanalysis Global Cloud Archive is described briefly in a paper by Henderson-Sellers and Hughes [5].

The 3D-NEPH model is described by Fye as being an automated system to process and interpret the tremendous volume of satellite data, integrating these data with conventional cloud information, and constructing a high quality, timely data base for multiple users. The 3D-NEPH model uses Defense Meteorological Satellite Program (DMSP) and some NOAA polar orbiting satellite data (no geosynchronous data are used in the model). With two DMSP satellites in orbit, observations are available four times each day (plus the occasional observations from the NOAA satellites). Visible and IR observations are used from the daytime orbits and IR from the nighttime orbits. The 3D-NEPH also depends heavily on output from other automated Air Force programs, such as Northern and Southern Hemisphere analyses, automated quality control, temperature analysis and forecast, and sea surface temperature analysis.

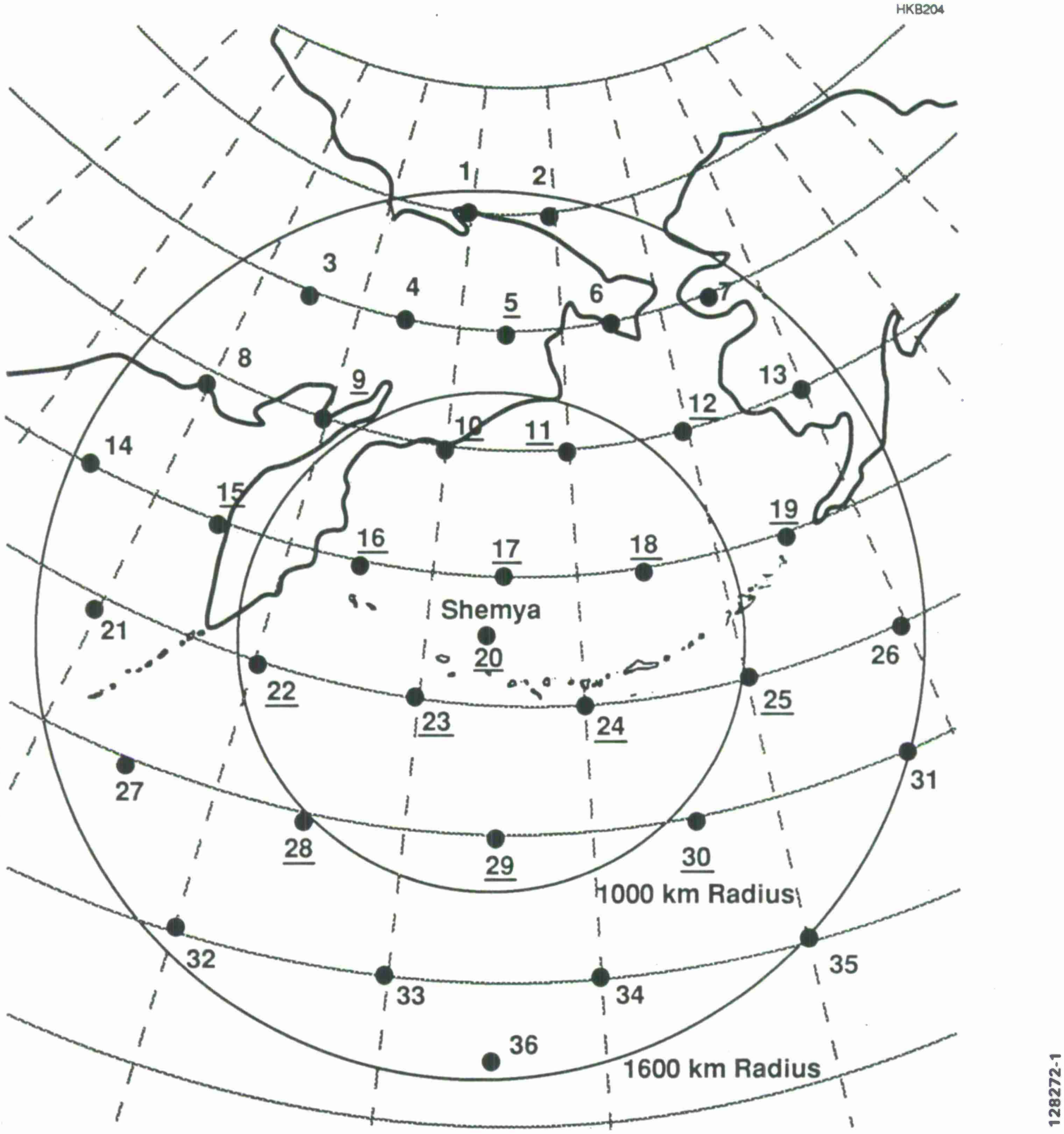


Figure 2-1. Map showing grid-point locations for Shemya cloud amount data set. The 18 locations within approximately 1,000 km of Shemya are underlined.

TABLE 2-1
Shemya – Coordinates of Cloud Grid-Point Locations

Grid-Point Number	Latitude	Longitude
1	70.16°N	169.90°E
2	70.12°N	179.46°E
3	65.05°N	154.58°E
4	65.13°N	165.30°E
• 5	65.23°N	175.20°E
6	65.05°N	175.19°W
7	65.05°N	164.81°W
8	60.08°N	149.86°E
• 9	60.07°N	160.36°E
• 10	59.92°N	169.94°E
• 11	59.92°N	179.70°E
• 12	59.95°N	170.00°W
13	59.92°N	159.70°W
14	54.80°N	145.00°E
• 15	55.20°N	154.89°E
• 16	55.17°N	165.07°E
• 17	55.05°N	175.26°E
• 18	55.17°N	175.13°W
• 19	55.17°N	164.87°W
• 20	52.33°N	174.33°E (Shemya AFB)
21	49.98°N	150.36°E
• 22	49.98°N	160.33°E
• 23	50.16°N	169.96°E
• 24	50.18°N	179.81°E
• 25	49.94°N	170.00°W
26	50.18°N	159.81°W
27	44.97°N	155.23°E
• 28	44.85°N	164.92°E
• 29	44.93°N	174.89°E
• 30	45.00°N	174.99°W
31	45.00°N	165.01°W
32	39.98°N	160.13°E
33	40.11°N	169.85°E
34	39.88°N	179.87°W
35	40.15°N	170.00°W
36	37.10°N	175.07°E

The 18 grid-point locations within approximately 1000 km of Shemya are indicated by bullets.

Digitization, formatting, and normalizing are important parts of the processing of the satellite data. The digitized imagery are stored in the Satellite Global Data Base (SGDB), which is gridded onto a projection coinciding with the 3D-NEPH grid. An IR data processor then combines information from the SGDB, temperature data base, background brightness data base, and geography/terrain fields to produce the independent cloud analysis data base; the data base produces cloud top height information as well as total cloud amount.

The 3D-NEPH grid system has a horizontal resolution of 25 nmi (based on operational requirements, accuracy of satellite data mapping, and areal extent of a typical surface observation). Each hemisphere consists of a 512 × 512 array, which is divided into 64 "3D-NEPH Boxes," each containing 64 × 64 grid points; the boxes reduce the grid to manageable sections and enable special analyses over smaller areas.

The vertical grid has 15 levels. Factors that were considered in determining the vertical grid included system costs, IR satellite sensor accuracy, accuracy of ground-based cloud height reports, accuracy of temperature/moisture soundings, and operational requirements. The six lower levels of the vertical grid (surface to 3500 ft) are specified with regard to local terrain height. The nine higher levels are specified with regard to mean sea level (MSL); depending on the terrain elevation, some of the MSL levels may be "filled" by terrain layers.

According to the paper by Henderson-Sellers and Hughes [5], the one-year cloud distribution derived from the 3D-NEPH model compares adequately with widely used climatologies. The authors conclude that the 3D-Nephanalysis Global Cloud Archive offers a realistic global cloud distribution with certain exceptions. Two exceptions that could impact the North Pacific area are: (1) unreliable Antarctic and Arctic cloud distributions, partly the result of using primarily an IR processor; and (2) underestimation of West Coast stratus cloud, also assumed to be due to the use of the IR processor. Neither of these exceptions should be a problem, however, with regard to the application of the Shemya cloud climatology. The Antarctic/Arctic problem applies to cloud estimation over the ice caps; therefore, the arctic region in question is really to the north of the Shemya area (only the northernmost data points could, perhaps, be impacted during winter). The detection of low stratus cloud could presumably be a problem in the North Pacific, as well as off the West Coast, since stratus is prevalent in the Shemya area; however, any inaccuracies would affect only the lowest level cloud amounts, and not the higher cloud levels of most interest for the Shemya climatology.

The most significant bias in the 3D-NEPH model impacting the application of the Shemya cloud climatology is the underestimation of the highest level clouds [2]. Surface observers, of course, may underestimate high clouds because of intervening layers of lower cloud. When viewed from above, high thin cirrus cloud may not always be detected in satellite visible imagery. Moreover, cloud data derived from satellite IR sensors will have a bias toward lower cloud heights; when thin cirrus is present, the IR sensor will measure the cloud top as being warmer than it actually is, with the result that the cloud will appear to be at a lower height. Overall, therefore, the cloud amounts at the highest levels are actually somewhat greater than indicated in the cloud data set; for example, where the cloud amount is indicated to be about 10 percent, the actual amount is probably more like 20 percent [2]. The detection of cirrus clouds by satellite sensors has been discussed by Burke *et al.* [3] and Bauer *et al.* [1].

2.1.2 Processing of Cloud Data Set

The cloud climatology data set for the area within approximately 1600 km of Shemya were provided for 36 grid-point locations, including Shemya AFB (52.3°N and 174.3°E) and 35 other locations located between 40° and 70°N and spaced at 5-degree latitude and 10-degree longitude intervals. The 36 grid points are shown on the map in Figure 2-1, and their exact locations are listed in Table 2-1. To reduce the amount of data processing, the cloud data were output from the tape for only the 18 grid-point locations within approximately 1000 km of Shemya (the 18 locations are indicated in Figure 2-1 and Table 2-1).

The cloud data were acquired for six layers determined from the original 15 3D-NEPH levels (it had been decided that data for all 15 layers were not needed for the cloud climatology and would have provided an unmanageable amount of data). Table 2-2 shows the six layers and the corresponding 3D-NEPH layers. The lowest layer combines 3D-NEPH Layers 1 through 6 and extends from the surface to 3500 ft (1,068 m); the highest layer combines the highest two 3D-NEPH layers, and extends from 26,000 ft (7,925 m) to 55,000 ft (16,764 m). Most of the grid-point locations are over the ocean, so terrain elevation is not a problem.

The cloud data for each layer are in two forms: mean monthly cloud percent, and frequency of occurrence of cloud amount by month. Although the tapes contain data for all months, the data were processed only for four representative months (January, April, July, and October). For each location, the mean cloud percentages for each layer for each of the four months are plotted on one graph to facilitate seasonal comparison. The frequencies of occurrence of cloud amount for each layer are plotted on graphs for each of the four representative months; five cloud amounts are plotted: 0, 1–3, 4–6, 7–9, and 10 tenths.

2.2 TEMPERATURE AND MOISTURE PROFILES DATA SET

The atmospheric profiles are derived from the Air Force Summarized Analysis Data Set for approximately the same period as the cloud data (1977 to 1982). Because the profiles are from a different data set, however, the profile grid-point locations do not coincide exactly with the cloud data locations. The procedure used for processing of the tape was to select a profile grid point nearest to each of the cloud data points (and, within 5 degrees of the cloud grid point). Apparently, because of the spacing of the profile grid, the same profile grid point was at times selected for two cloud grid points, and no profile location data was selected for some cloud grid points. Nevertheless, atmospheric profiles for a representative number of locations within approximately 1000 km of Shemya were processed; the coordinates of the profile grid-point locations are listed in Table 2-3.

Temperature profiles are plotted for 16 standard pressure levels from the surface to 10 mb; the numbers of the levels, with corresponding pressures and heights, are given in Table 2-4 (it should be noted that the temperature profiles are plotted on a linear vertical scale with the heights corresponding to the numbers given in Table 2-4). Moisture profile data are only available up to the 300-mb level (Level 7 in Table 2-4); the moisture profiles are plotted in terms of dew point depression. As with the cloud data, the profile data are plotted for four representative months: January, April, July, and October.

TABLE 2-2
Layer Heights and Thicknesses of the Shemya Six-Layer Data Set with Corresponding 15 3D-NEPH Layers

Layer Number: 3D-NEPH	Layer Number: Shemya Data Set	Height (ft)	Height (m)	Pressure Level (mb)	Thickness (3D-NEPH) (ft)	Thickness (3D-NEPH) (m)	Thickness (Shemya) (ft)	Thickness (Shemya) (m)	Layer Number
			SURFACE						
1					150	(46)			
		150	(46) AGL						
2					150	(46)			
		300	(91) AGL						
3					300	(92)			
		600	(183) AGL				3500	(1068)	(1)
4					400	(122)			
	(1)	1000	(305) AGL						
5					1000	(305)			
		2000	(610) AGL						
6					1500	(457)			
		3500	(1067) AGL/MSL						
7					1500	(457)			
	(2)	5000	(1524) MSL	850			3000	(914)	(2)
8					1500	(457)			
		6500	(1981) MSL	800					
9	(3)				3500	(1067)	3500	(1067)	(3)
		10000	(3048) MSL	700					
10					4000	(1219)			
	(4)	14000	(4267) MSL	600			8000	(2438)	(4)
11					4000	(1219)			
		18000	(5486) MSL	500					
12					4000	(1219)			
	(5)	22000	(6706) MSL	430			8000	(2438)	(5)
13					4000	(1219)			
		26000	(7925) MSL	360					
14					9000	(2743)			
	(6)	35000	(10668) MSL	240			29000	(8839)	(6)
15					20000	(6096)			
		55000	(16764) MSL	100					

TABLE 2-3
Coordinates of Profile Data Points

Point Number	Coordinates	Corresponding Cloud Point; Other Comments
5	65°N 175°E	5 (same)
9	60°N 160°E	9 (same)
10	60°N 170°E	10 (same)
11	55°N 175°E	17
12	55°N 165°W	19
14	55°N 145°E	—
15	55°N 155°E	15 (same)
16*	60°N 170°E	10 (same as 10 above)
17	52.43°N 174.06°E	20 (Shemya)
18	55°N 175°W	18 (same)
19	—	
20	50°N 170°E	23
21	50°N 150°E	—
22	50°N 160°E	22 (same)
23	55°N 165°E	16
24*	55°N 175°E	17 (same as 11 above)
25	50°N 170°W	25 (same)
27	45°N 155°E	—
28	45°N 165°E	28 (same)
29	45°N 175°E	29 (same)
30	45°N 175°W	30 (same)

* Point numbers 16 and 24 were repeat data, so were removed from the data set.

TABLE 2-4
Level, Pressure and Altitude Equivalents for Atmospheric Profile Data

Level Number	Pressure (mb)	Height (m)*
1	sfc	—
2	1000	111
3	850	1,457
4	700	3,012
5	500	5,574
6	400	7,185
7	300	9,164
8	250	10,363
9	200	11,784
10	150	13,608
11	100	16,180
12	70	18,442
13	50	20,576
14	30	23,849
15	20	26,481
16	20	31,055

* Taken from U. S. Standard Atmosphere, 1976 [7].

2.3 OTHER RELEVANT DATA

Few other sources of cloud climatology data exist for the North Pacific, so the accuracy of the data set is difficult to ascertain; however, as mentioned in Section 2.1, a study by Henderson-Sellers and Hughes [5] reported that a one-year cloud distribution derived from the 3D-NEPH model compared favorably with widely used climatologies. There are, of course, inherent limitations to the data set because the 3D-NEPH model integrates satellite-derived cloud cover with conventional cloud observations from surface and aircraft. The basic differences between ground-observed and satellite-derived climatologies, with ground observers viewing cloud bottoms and satellites viewing primarily cloud tops, have been discussed by Hughes [5] and Hwang *et al.* [6]. The most significant bias in the data set is probably the underestimation of high clouds (discussed in Section 2.1) because of: (1) the surface observer not seeing higher clouds due to intervening lower cloud layers; (2) high thin cirrus not being detected by satellite visible sensors; and (3) satellite IR sensors showing high thin cirrus to be warmer, and thus at a lower height, than these clouds actually are.

Other recently derived global cloud climatology data sets may also provide useful cloud statistics for the North Pacific area. These data sets are being compiled in response to the requirement for an accurate, global cloud climatology, internationally recognized in the establishment of the International Satellite Cloud Climatology Project (ISCCP), discussed by Schiffer and Rossow [8]. One data set available for climate studies is the Nimbus-7 Global Cloud Climatology, described by Stowe *et al.* [9] and Hwang *et al.* [6], which is a six-year (1979 to 1985) global cloud climatology derived from Nimbus-7 satellite IR and UV radiance data. This data set also uses concurrent surface temperature and snow/ice information from the 3D-NEPHS archive. The Nimbus-7 cloud products include values of total cloud amount, cloud amount in high, middle, and low altitude categories, cirrus cloud amount, and radiances of cloud and clear scenes; these products are stored on tape with approximately 165 × 165-km resolution.

As discussed with regard to the limitations of the 3D-NEPH model, Hwang *et al.* [6] point out that retrieval of cloud fields from satellite measurements is neither an exact science nor a rigidly codified routine; thus, although the Nimbus-7 cloud estimates appear quite realistic when compared with concurrent GOES satellite images, considerable differences are noticed when the estimates are compared to other climatologies, including the ISCCP data set. For example, in one month (July 1983) the Nimbus-7 set estimated a global mean cloud cover of 49 percent as compared to a 63-percent estimate by a preliminary ISCCP algorithm; even larger regional differences were noted.

All global cloud climatology data sets, or data sets for ocean regions with few reporting stations, must be based on satellite observations. Although these data sets all have certain inherent limitations, they do provide the most useful cloud statistics available.

3. DISCUSSION OF CLOUD CLIMATOLOGY

Since the Shemya/North Pacific cloud climatology is based on the 3D-NEPH model, which is derived primarily from satellite observations, the climatology presents the cloud statistics essentially as viewed from above. The cloud statistics indicate that when viewed from above, there is overall a high percentage of cloud cover throughout the North Pacific area, especially at the lower cloud layers; thus, although the highest layers may have little cloud, the surface will be completely obscured by lower level clouds much of the time.

The cloud statistics indicate some geographic differences in cloud cover, with certain locations having a consistently greater percentage of cloud amount. In general, the northernmost locations tend to have less cloud; the areas with greater cloud amounts are near the Kamchatka Peninsula and along the Aleutian chain near Shemya itself. Some seasonal cloud differences are also indicated, but, overall, do not appear to be very significant.

The layer-to-layer cloud amount differences, which are quite significant, as well as the geographic and seasonal differences, are discussed for both the mean cloud amount and percent frequency of cloud amount in the following sections.

3.1 MEAN CLOUD PERCENT

3.1.1 Layer-to-Layer Differences

The plots of mean cloud percent for January, April, July and October are shown in Appendix A. Overall, the cloud climatology shows greater mean cloud amounts at the lower layers; some locations show significant differences in cloud amount, although a few locations have similar cloud percentages for all layers. For Layer 6, the highest layer (7,925 m to 16,764 m), the greatest mean cloud amount is 32 percent (Location 15 in January) and the least amount is 2 percent (Location 11 in both April and July). For most locations, the mean cloud amount for Layer 6 is less than 10 percent; for only four of 18 locations is the cloud amount consistently greater than 10 percent. As discussed earlier, however, the cloud amounts are likely to be underestimated at levels where cirrus clouds prevail; thus, the mean cloud amounts are likely to be as much as 10 percent greater than those plotted from the 3D-NEPH data set.

For the lowest cloud layer (Layer 1, surface to 1,067 m) the greatest mean cloud amount is 85 percent at Shemya, itself; the least amount is 14 percent at Location 5, the farthest north location over eastern Siberia, in April. In fact, this location is the least cloudy location overall, with Layer 1 having less than 50 percent cloud cover in all four months; for 12 locations the Layer 1 cloud amount exceeds 50 percent for all months.

The intermediate cloud layers either show an increase in cloud amount from Layer 5 down through Layer 2, or have similar cloud amounts at all layers. In general, there are no "peaks" in cloud amount at midlevels, although the maximum cloud amount does occur at a middle layer (usually Layer 4; 3,048 to 5,486 m) for a few locations during one or two months.

3.1.2 Geographical Differences

Overall, the northern locations have less cloud, especially Location 5, which has the smallest mean cloud percentages at all layers except Layer 6 (note: Grid-Point 5 is a land location, in easternmost Siberia). The northern areas also tend to have smaller layer-to-layer differences, whereas the more southern locations tend to have maximum cloud amounts consistently at the lower layers. The locations with overall greatest mean cloud percentages are Location 16 (just off the Kamchatka Peninsula), Location 19 (eastern Aleutians), and Location 20 (Shemya). Table 3-1 shows the mean cloud percentages for January and July for one of the least cloudy locations (Location 5) and one of the most cloudy locations (Shemya, Location 20); Location 5 actually has slightly greater cloud amounts at the highest two layers in both months (although the percentages are relatively small), but Shemya has much greater cloud amounts at the middle and lower layers.

3.1.3 Seasonal Differences

The seasonal differences for all locations, in general, are not pronounced; thus, the four months selected for processing are believed to be representative. For a few locations the greatest cloud amounts at the lower layers are during the summer (July); for example, both Grid-Points 5 and 20 (Table 3-1) have significantly greater cloud amounts at the three lowest layers in July as compared to January. Other locations, however, do not show this same trend.

The higher layers, especially Layer 6, show a smaller month-to-month variation. The northern data points do tend to have slightly greater cloud amounts in January and April, whereas the southern areas tend to have lesser cloud amounts in January.

TABLE 3-1

Comparison of Mean Monthly Cloud Percentages for Two Locations: Grid-Points 5 (Eastern Siberia) and 20 (Shemya AFB)

Layer Number	August		July	
	Location 5 (Percent)	Location 20 (Percent)	Location 5 (Percent)	Location 20 (Percent)
6	13.1	5.5	11.8	7.4
5	19.8	17.7	19.4	18.2
4	32.3	42.3	33.1	41.1
3	14.0	48.2	31.7	67.3
2	17.3	64.0	47.0	78.6
1	18.9	57.3	48.2	85.2

3.2 PERCENT FREQUENCY OF CLOUD AMOUNT

The percent frequency of cloud amount data is similar to the mean cloud percent data except that these graphs, shown in Appendix B, indicate the percentage of time a particular cloud amount occurs at each layer. The cloud amounts in tenths are: 0 (no cloud), 1–3, 4–6, 7–9, and 10 (completely cloudy).

The percentage of time with no cloud is very high for the upper layers, being as much as 90 percent at some locations. The minimum frequency of no cloud at Layer 6 is 45 percent at Grid-Point 11 in January. As discussed earlier, these frequencies of no cloud are probably somewhat too high at Levels 5 and 6. Most locations show a smaller frequency of no cloud at the lower layers; for example, the percentage of time with no cloud at the lowest layer at Shemya (Location 20) in July is only 5 percent. The eastern Siberia (Location 5) has a high percentage of no cloud at all layers in January, being 67 percent even at the lowest layer.

Correspondingly, the frequency of occurrence of completely cloudy or mostly cloudy conditions (10 or 7–9 tenths) is low at the upper layers. At Layer 6, only one location has a frequency of 10 tenths exceeding 10 percent (Grid-Point 15); most locations have frequencies less than 10 percent in all months, and some have frequencies as low as less than 1 percent.

At the lowest layer, the frequency of occurrence of 10 tenths cloud exceeds 25 percent at most locations, with some exceeding 50 percent. For example, the frequency of occurrence of 10 tenths cloud at Shemya in July is 63 percent. In fact, Shemya in July has perhaps the greatest layer-to-layer variation in cloud of any location in the data set; at Level 6, Shemya has an 87 percent frequency of 0 tenths cloud, whereas at Level 1, this data point has a 63-percent frequency of 10 tenths cloud. Most locations have a considerably smaller layer-to-layer variation in percent frequency of cloud amount.

The geographic and seasonal variations in percent frequency of cloud amount are similar to the variations in mean cloud percent discussed in Section 3.1. Overall, the greatest frequency of occurrence of completely cloudy or nearly cloudy conditions is observed at the lowest layers during summer.

4. DISCUSSION OF ATMOSPHERIC PROFILE DATA

4.1 TEMPERATURE PROFILE DATA

The temperature and moisture profile data are shown in Appendix C. As discussed in Section 2.2, the profiles were plotted for 18 grid-point locations within approximately 1000 km of Shemya; the coordinates of the profile grid points, shown in Table 2-3, are approximately those of the cloud data set.

The temperature profiles show considerable seasonal variations, with nearly all profiles being warmer in summer, especially at lower levels. At the surface, temperatures are as much as 20° to 25°C higher in summer, ranging from -10°C in January to 15°C in July at Location 5 (eastern Siberia) and 5°C in January to 25°C in July at Location 30 (ocean at 45°N). In general, the southern locations have surface temperatures as much as 10° to 15°C higher in all seasons and have warmer atmospheres up to the tropopause.

At upper levels, variation in the height of the tropopause is evident at some locations. The tropopause is the level of minimum temperature dividing the troposphere from the stratosphere. At northern latitudes, even the highest level cirrus cloud would be below the tropopause level; thus, the tropopause can be considered as the upper limit for cloud formation. At the three most southern locations, a pronounced summertime tropopause occurs at 100 mb (Level 11; 16,180 m); the wintertime tropopause is as low as 300 mb (Level 7; 9,164 m) at these locations, but is not as pronounced as in summer. The tropopause is also well defined at the 100-mb level at Shemya in July and October, but is not well defined at several other northern locations.

Throughout the data set, the tropopause temperatures are generally about -50°C, but are as low as -70°C at Shemya in July. The tropopause temperatures at the three most southern locations are as high as -45° to -40°C in January (at the 300-mb level), and as low as -60°C in July (at the 100-mb level). The temperature range from the surface to the tropopause, therefore, is 25° to -60°C in July, but only 5° to -45°C in January. At the northern areas, the tropopause temperatures are about -50°C all year, occurring at the 250- to 300-mb level; since the surface temperatures are lower, the surface-to-tropopause temperature ranges are considerably less than at the southern areas.

The temperature profiles appear to have some discrepancies, especially when Shemya (Location 17; 52.43°N, 174.06°E) is compared with nearby locations (Location 11; 55°N, 175°E; Location 20; 50°N, 170°E). The Shemya profile is rather different in all four months than the profiles at the other two locations, which are quite similar; in particular, the very pronounced tropopause at Shemya is not evident at the other two nearby locations. Moreover, the surface temperatures seem to vary considerably, with Shemya being as much as 15° to 20°C warmer than the other locations. The surface temperature at Shemya is about 25°C in October and more than 25°C in July; based on general climatological considerations, these temperatures seem too high. The temperatures at the higher levels above the tropopause are in better agreement among the three data points than are the temperatures at lower levels.

4.2 MOISTURE PROFILE DATA

The moisture profiles are only available from the surface to the 300-mb level (9,164 m), and are plotted in terms of dew point depression. The dew point depression at the surface is uniformly in the 2° to 4°C range; and most profiles are quite dry with relatively large dew point depressions at the 300-mb level. Essentially, no profile shows greater moisture at any level above the surface; in most profiles, the atmosphere dries out gradually above the surface or remains about the same for several levels and then dries out rapidly. A few profiles dry out above 850 mb and then have a layer of increased moisture at a higher level, generally near 400 mb. This type of profile is especially pronounced at Shemya; in April, July, and October, the dew point depression exceeds 20°C at 700 mb, but is only 10° to 12°C at the 500- to 400-mb level.

Overall, the moisture profiles do not exhibit much seasonal or geographical variation. Moreover, none of the profiles indicate any significant moisture that could be related to probable cloud layers; therefore, the moisture profiles do not provide useful information for cloud climatology purposes.

5. ESTIMATION OF CLOUD TOP HEIGHTS AND TEMPERATURES

5.1 CLOUD TOP HEIGHTS

Mean cloud percent and percent frequency of cloud amount present the cloud statistics in somewhat different formats. Neither format permits a single overall cloud amount to be derived because the statistics are given for the six separate cloud layers. For viewing the clouds from above, the layer with the greatest mean cloud percent can be considered the limiting cloud amount for viewing the surface or lower cloud layers; thus, if a midlayer has a greater cloud amount than the layers below it, the midlayer prevails when looking down from above. In general, however, the cloud amounts increase downward, with the lower layers having the greatest cloud amounts.

The height of the upper boundary of a cloud layer can be used to estimate the cloud top height for that particular layer since the mean cloud amount given is the integrated cloud amount throughout the layer. For example, it may be desired to know the cloud top height of the highest layer with more than 30 percent cloud or the highest layer with a more than 50 percent frequency of occurrence of 7–9 tenths cloud; these could be Layer 3, so the estimated cloud top height would be the upper boundary of Layer 3 or 3,048 m (from Table 2-2).

For the highest layers, the estimated cloud top heights would be somewhat less accurate because the extents of the layers are much greater than they are for the lower layers. Moreover, the problems in detecting high, thin cirrus, discussed previously (i.e., the satellite IR sensor will show the thin cirrus to be warmer, and thus lower than actuality), will impact the estimates of cloud top heights. The temperature profiles can be used in these instances, at least to provide upper limits to the estimated cirrus cloud top heights. For example, the tropopause at Shemya in July is at the 100-mb level (16,180 m); the highest cirrus could, therefore, be close to that height, which is the upper limit of Layer 6. At another location, however, the tropopause in January is at 300 mb (9,164 m); although this altitude also falls into Layer 6, the limiting cloud top height would be at the tropopause (9,164 m) rather than at the top of Layer 6 (16,764 m).

5.2 CLOUD TOP TEMPERATURES

Cloud top temperatures can be estimated from the cloud top heights and temperature profiles. For example, at Location 19 in July, Layer 3 has a mean cloud amount of more than 50 percent. The upper boundary of Layer 3 is 3,048 m (from Table 2-2). The corresponding profile is for Location 12 (from Table 2-3); in July, the temperature at the height of 3,048 m, which is Level 4 (the 700-mb level), is about 2°C. This, therefore, is the estimated cloud top temperature for that layer.

In another example, at Location 10, Layer 4 has a mean cloud amount of nearly 50 percent in January; the top of Layer 4 is at 5,486 m (the 500-mb level). From the temperature profile for Location 10, the temperature at the 500-mb level (Level 5) is -35°C, which would be the estimated cloud top temperature.

5.3 OVERALL ESTIMATED CLOUD TOP TEMPERATURES

Although it is difficult to give overall estimates of cloud top temperatures because of varying cloud amounts at the different layers, some generalities are possible. The upper limit of cirrus clouds can be estimated from the level of the tropopause. In January, the tropopause is consistently at the 300- to 250-mb level (9,164 to 10,363 m), where the temperature range is -40° to -50°C; these values, therefore, can be considered to be the lowest possible temperatures of the highest level (cirrus) cloud tops.

In July, the tropopause at most locations is at about the same level as in winter, with similar temperatures. Exceptions are Shemya with a distinct tropopause at 100 mb (16,180 m) and a temperature of -70°C, and the three southernmost locations, which also have tropopause levels at 100 mb with temperatures -55° to -60°C. The Shemya temperature appears to be out of line with the other locations (the other three locations with the tropopause at 100 mb are all 10 to 15 degrees warmer at that level); furthermore, even in summer, cirrus would generally be expected to be at a somewhat lower level than 16,000 m. Thus, an overall cloud top temperature in summer for the highest level cirrus would realistically be in the -50° to -60°C range. As discussed earlier, many locations have mean cloud amounts at the cirrus level of only about 20 percent.

The highest cloud layer with mean cloud amounts consistently greater than 30 percent, and some locations near 50 percent, is Layer 4 (3,048 to 5,486 m). Temperatures at the upper boundary (near the 500-mb level) range from -25° to -30°C in January and -10° to -15°C in July. Clouds at this level could be middle cloud or lower level cirrus; thus, these temperatures could be considered to be the cloud top temperatures for the highest layer with cloud amounts generally equal to or greater than 30 percent.

Most data points have a substantial amount of cloud at Layer 2, often greater than 50 percent and at times exceeding 70 percent. The upper boundary of this layer is at 1,981 m (800 mb). From the profiles, temperatures at this level are generally in the -15° to -5°C range in winter and 10° to 15°C in summer; thus, clouds with these cloud top temperatures can be anticipated more than 50 percent of the time.

6. CONCLUSION

The Shemya/North Pacific cloud climatology data set presents monthly statistics of mean cloud percent and frequency of occurrence of cloud amount for 18 grid-point locations within approximately 1000 km of Shemya (52.3°N, 174.3°E). The cloud statistics are derived from the Air Force 3D-Neph-analysis Global Cloud Archive (3D-NEPH Model) for the period 1977 to 1983. These cloud statistics, together with atmospheric temperature profiles derived from the Air Force Summarized Analysis Data Set, are used to determine estimates of cloud top heights and temperatures for six layers from the surface to 16,764 m (100-mb level).

Since the cloud climatology is derived from satellite data, the inherent limitations of satellite cloud observations must be taken into account. Nevertheless, since few other sources of cloud climatology data exist for the North Pacific, the satellite data base provides the most useful cloud statistics available.

The cloud statistics indicate an overall high percentage of cloud cover in the North Pacific area, particularly at the lower cloud layers. Considerably smaller percentages of high cloud are indicated. The statistics show some geographic differences, with northernmost locations tending to have less cloud and locations near Kamchatka and along the Aleutian island chain having greater average cloud amounts. Seasonal variations in cloud cover are small.

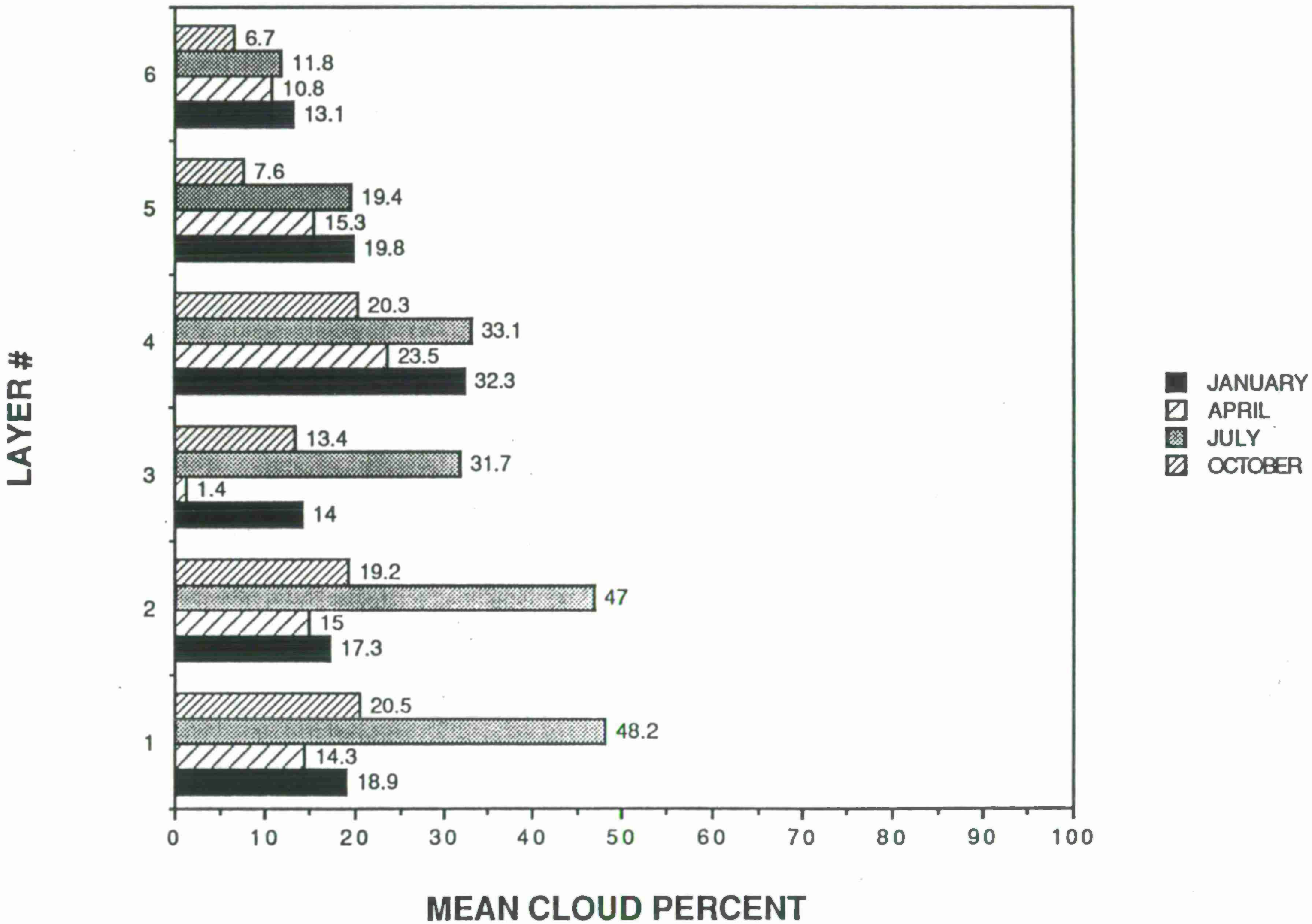
Although it is difficult to derive overall estimates of cloud top heights and temperatures, the upper limit of high cirrus in winter is indicated to be at about the 9,000- to 10,000-m level with a cloud top temperature of -40° to -50°C; in summer, the cirrus level can be higher, approaching the 16,000-m level, with a cloud top temperature of -50° to 60°C. The highest cloud layer with amounts consistently greater than 30 percent, and in some locations near 50 percent, is at about the 3000- to 5500-m level with cloud top temperatures of -25° to -30°C in winter and -10° to -15°C in summer.

APPENDIX A

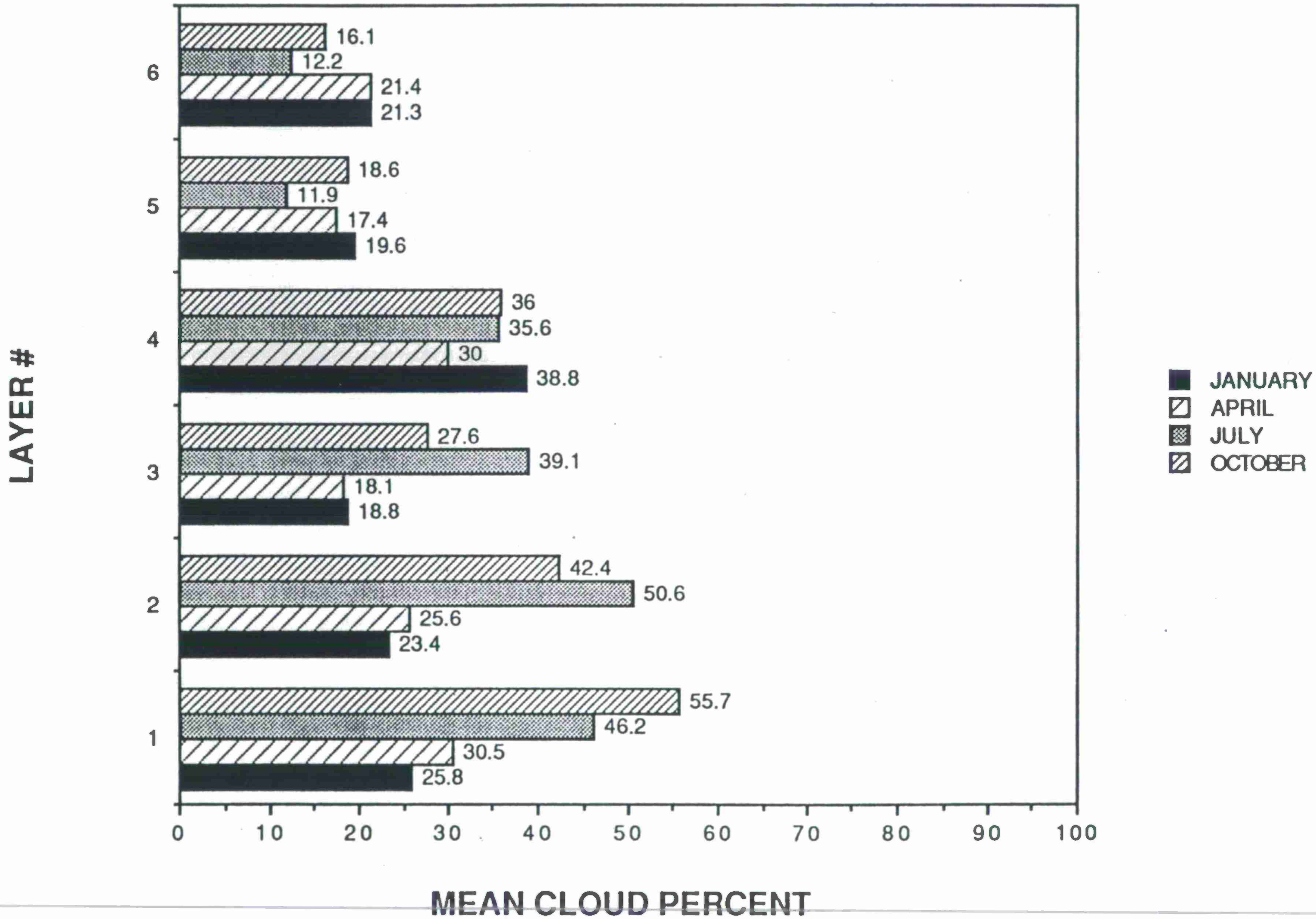
MEAN CLOUD AMOUNT STATISTICS

(January, April, July, October)

MEAN CLOUD PERCENT COMPARISON FOR 65.23 N 175.20 E (5)

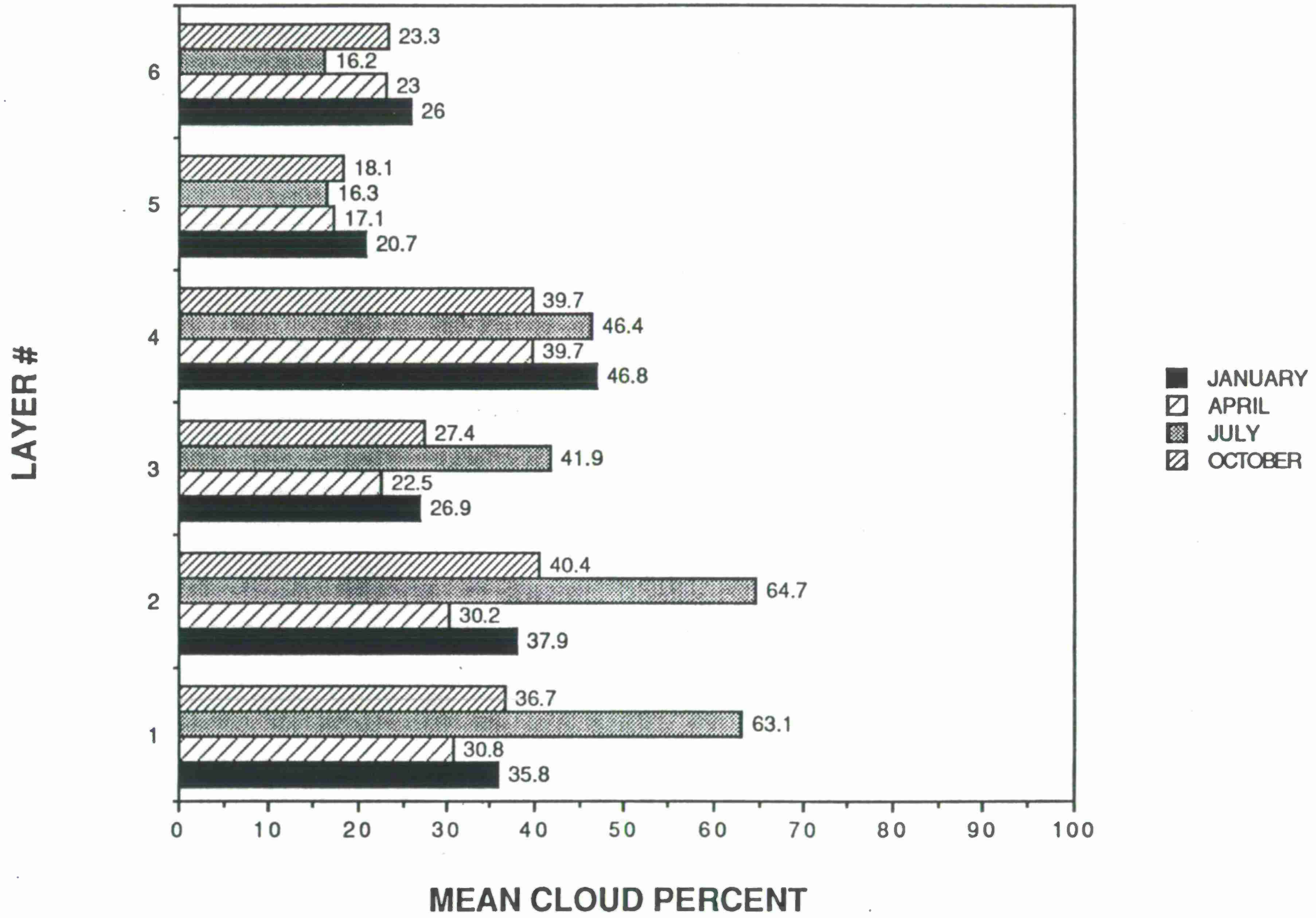


MEAN CLOUD PERCENT COMPARISON FOR 60.07 N 160.36 E (9)

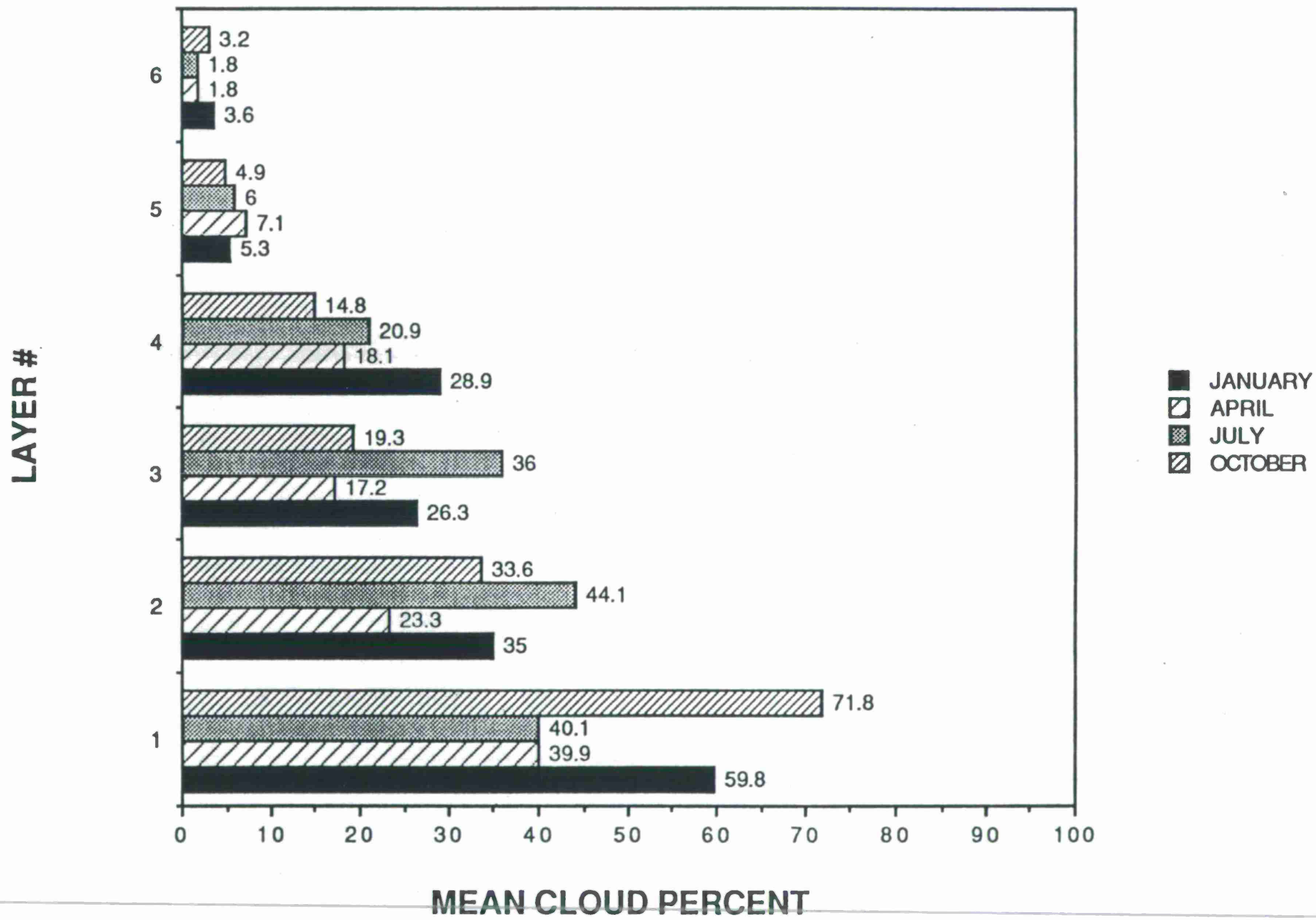


25

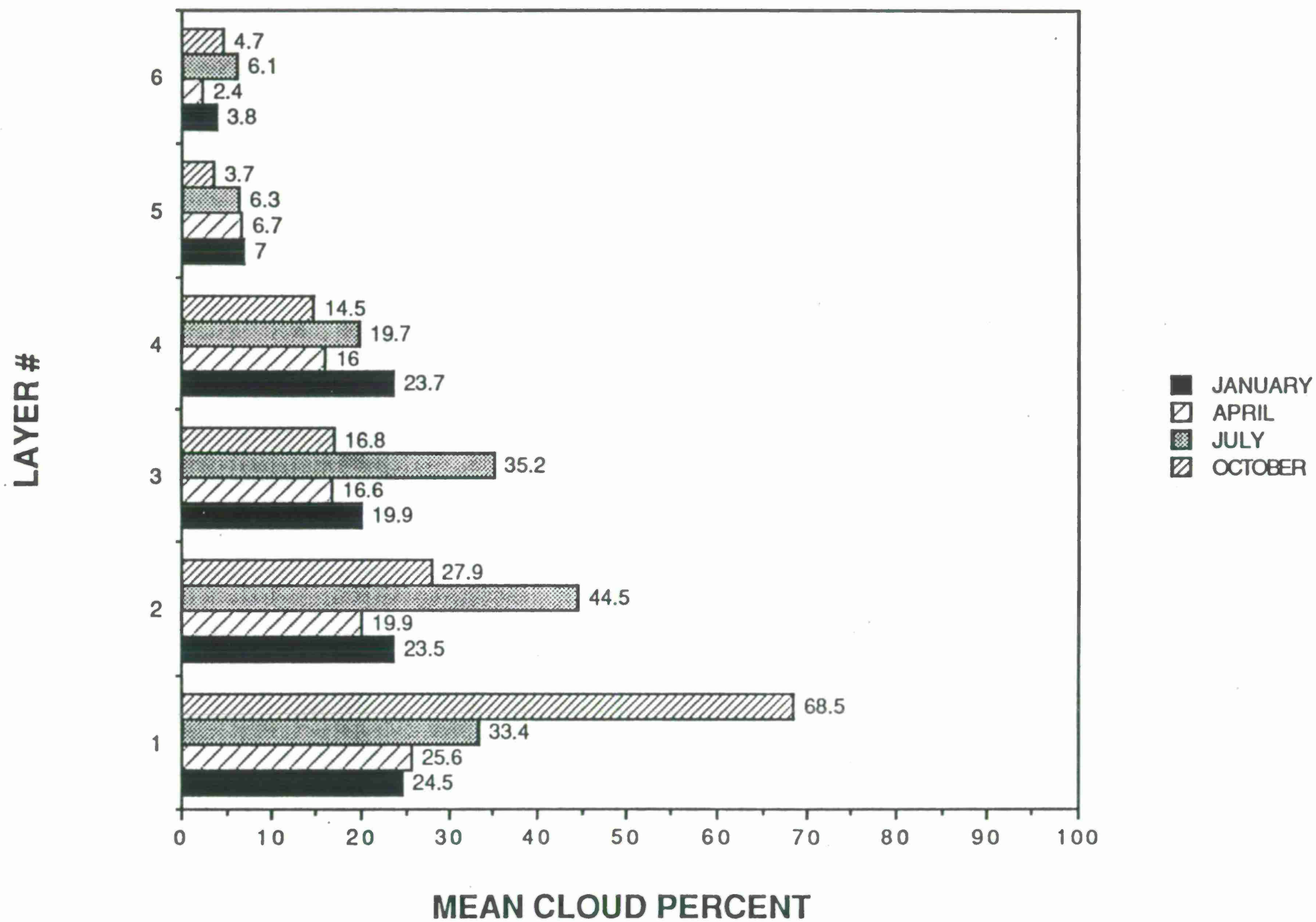
MEAN CLOUD PERCENT COMPARISON FOR 59.92 N 169.94 E (10)

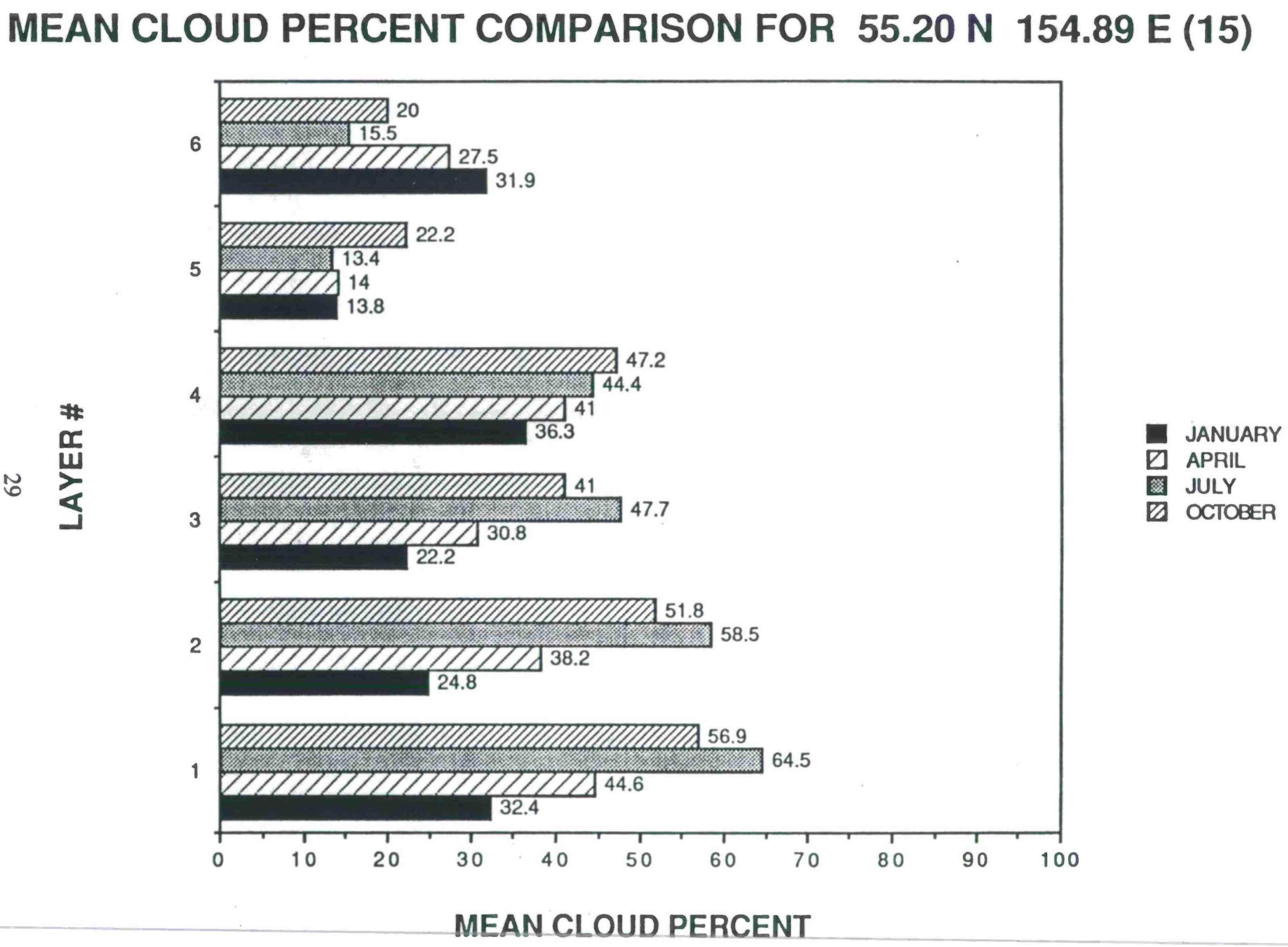


MEAN CLOUD PERCENT COMPARISON FOR 59.92 N 179.70 E (11)



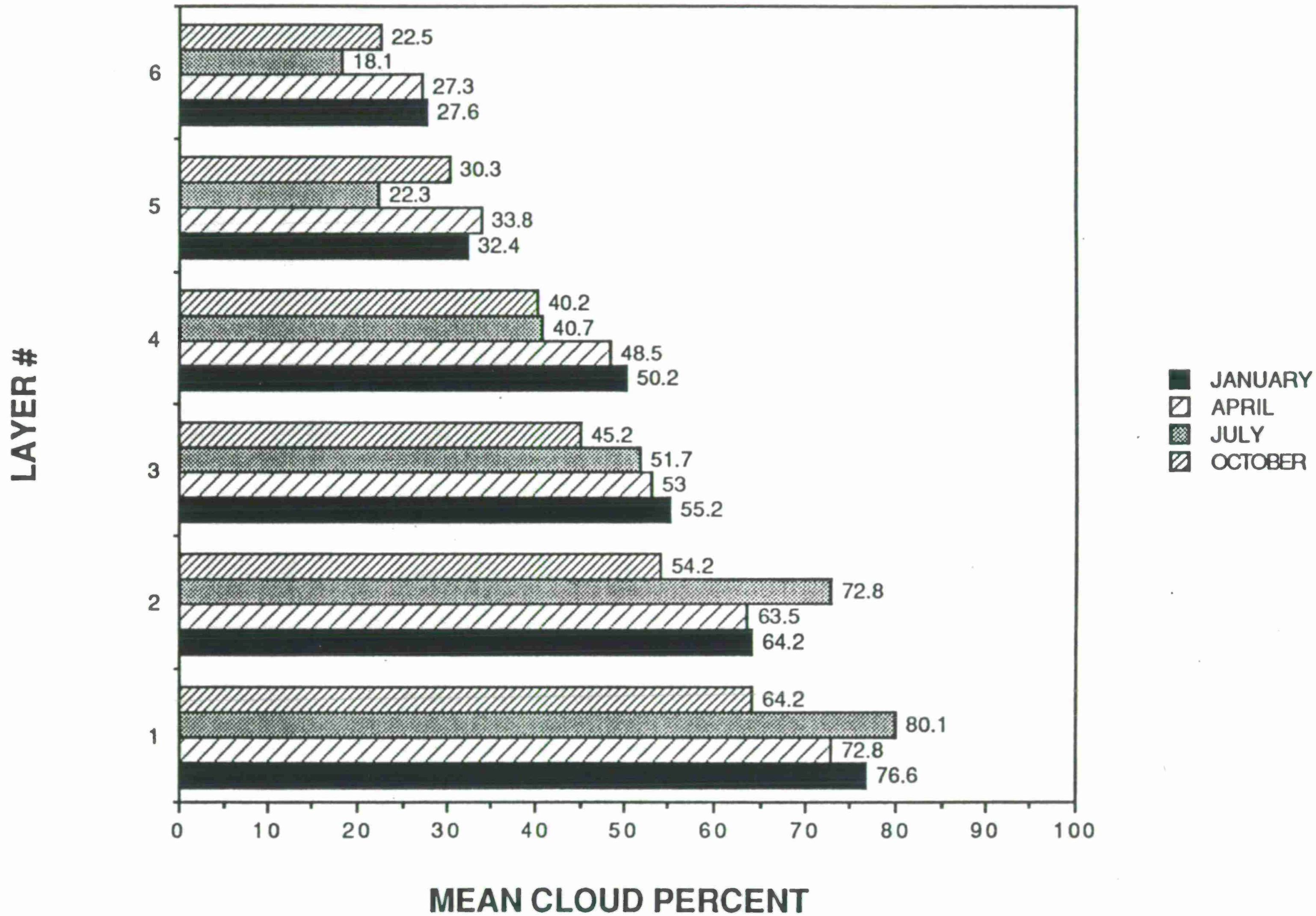
MEAN CLOUD PERCENT COMPARISON FOR 59.95 N 170.00 W (12)



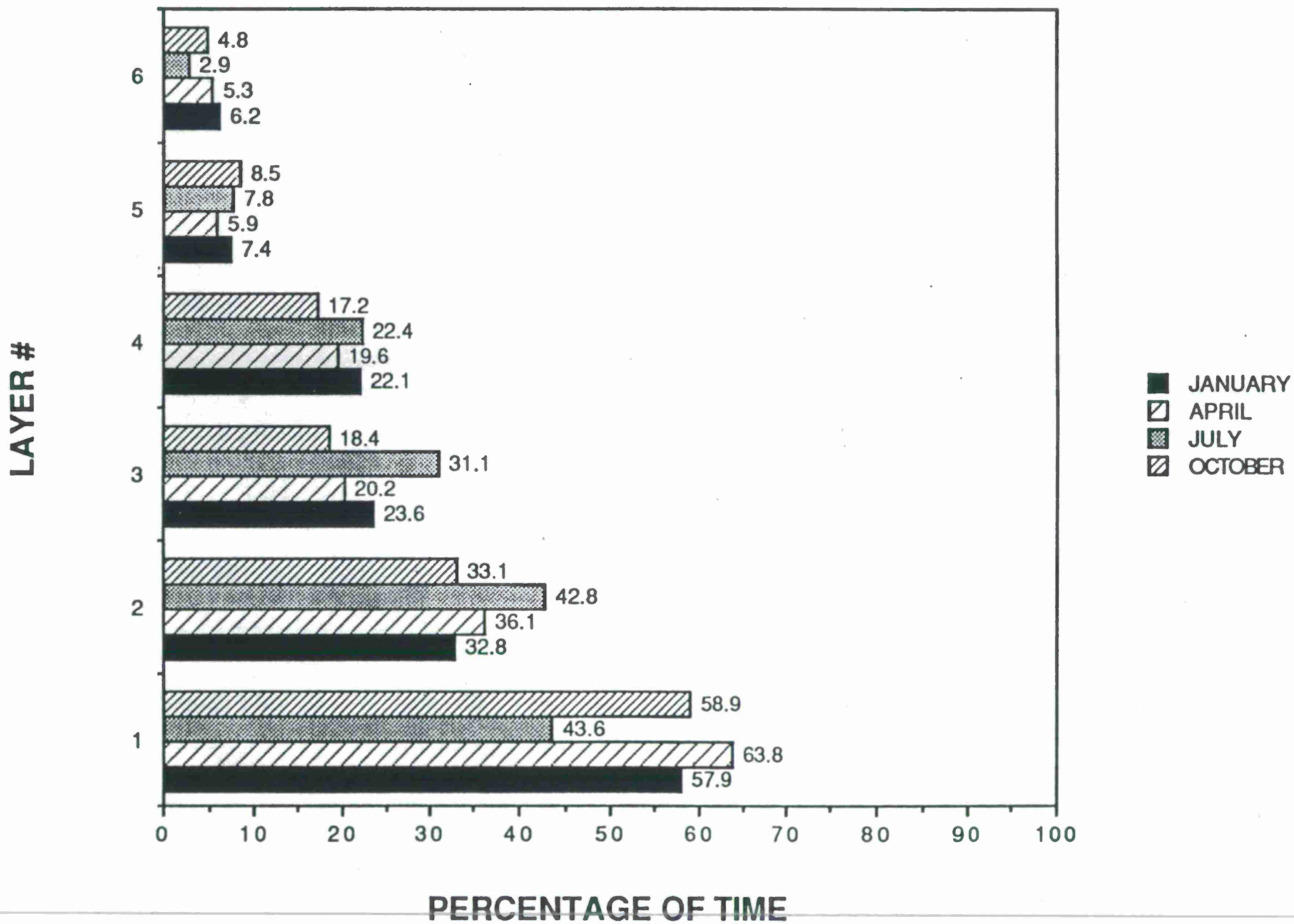


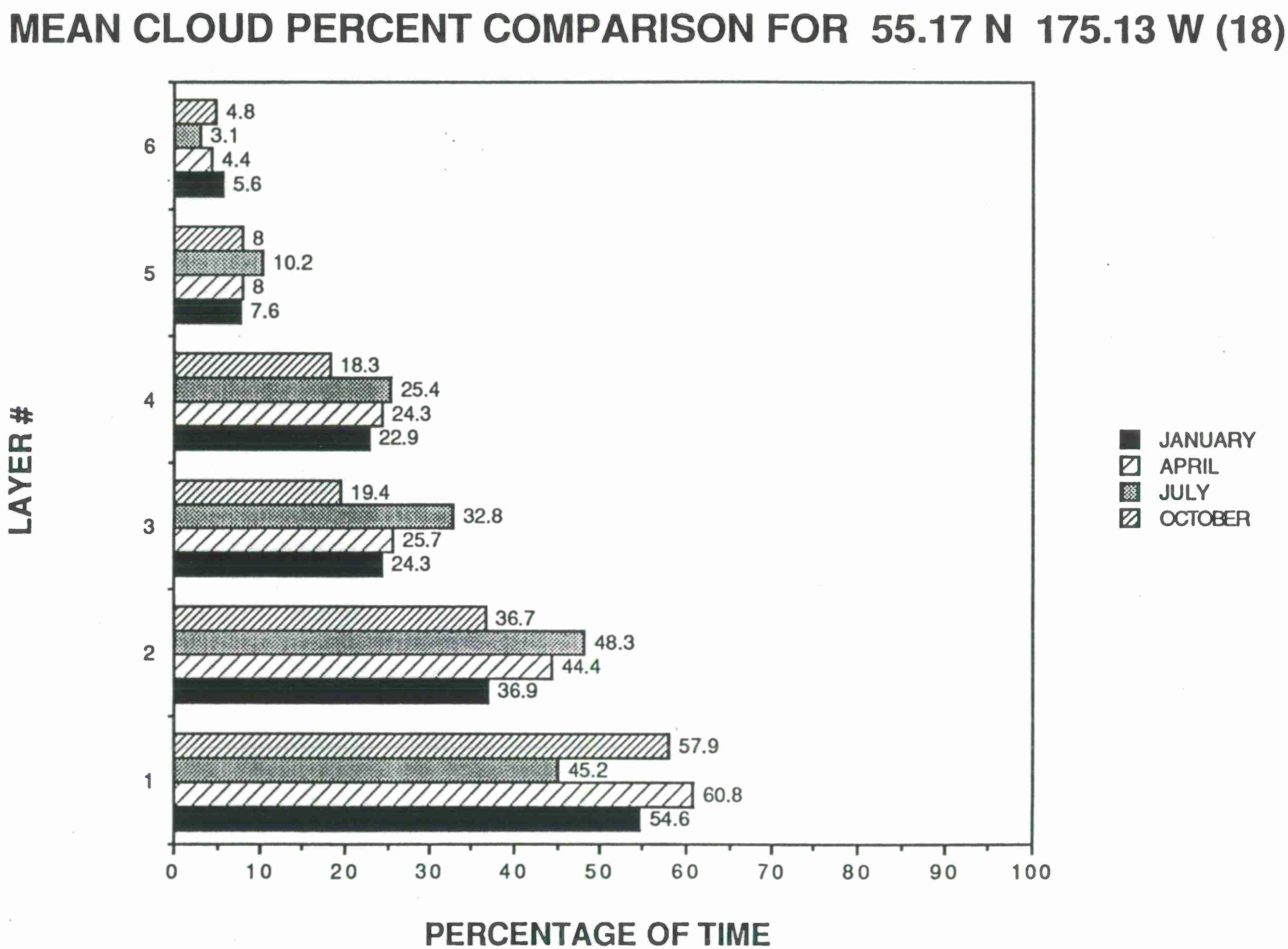
MEAN CLOUD PERCENT COMPARISON FOR 55.20 N 154.89 E (15)
LAYER #
6
5
4
3
2
1
20
15.5
27.5
31.9
22.2
13.4
14
13.8
47.2
44.4
41
36.3
41
47.7
30.8
22.2
51.8
58.5
38.2
24.8
56.9
64.5
44.6
32.4
0
10
20
30
40
50
60
70
80
90
100
MEAN CLOUD PERCENT
JANUARY
APRIL
JULY
OCTOBER

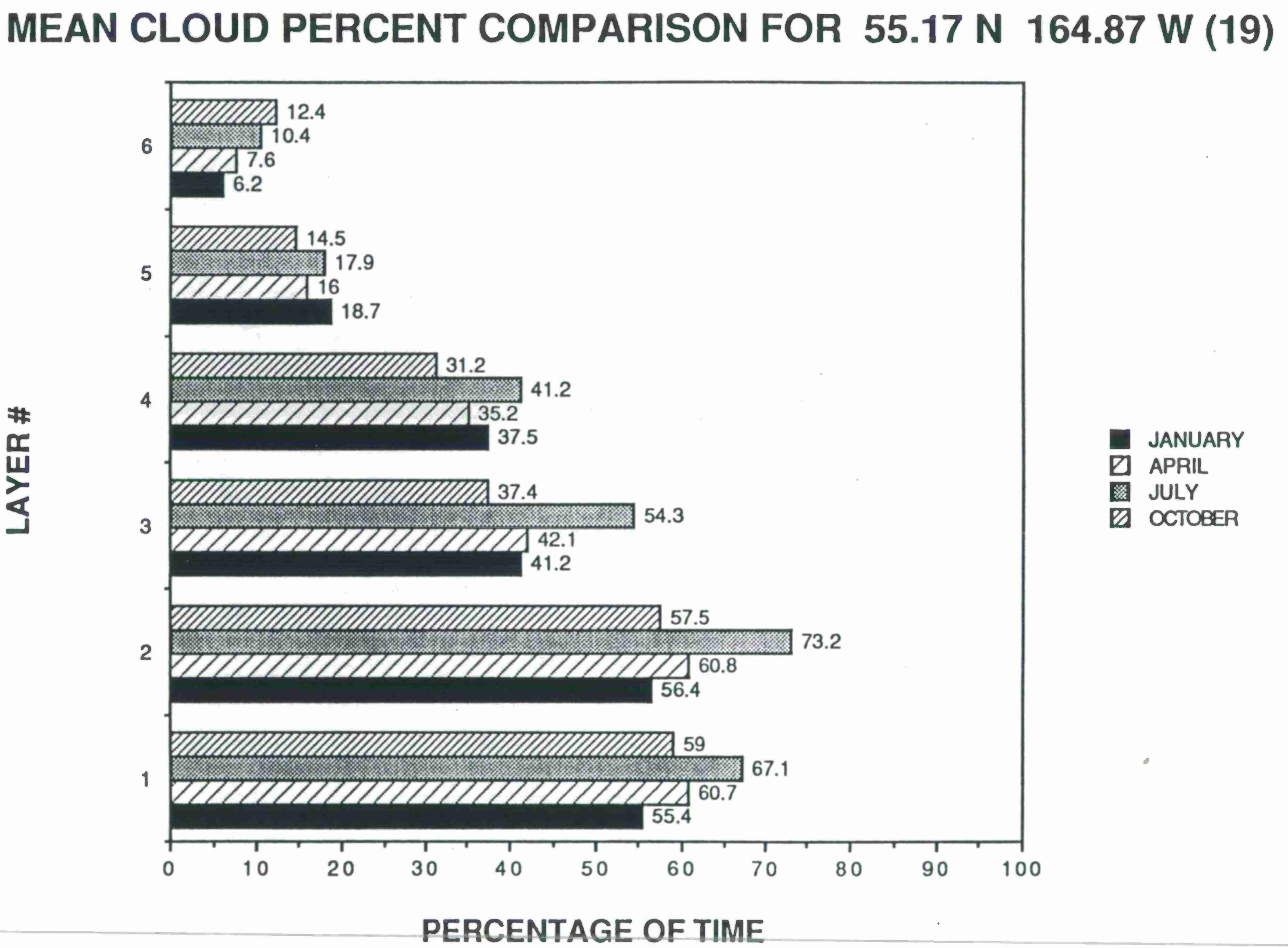
MEAN CLOUD PERCENT COMPARISON FOR 55.17 N 165.07 E (16)



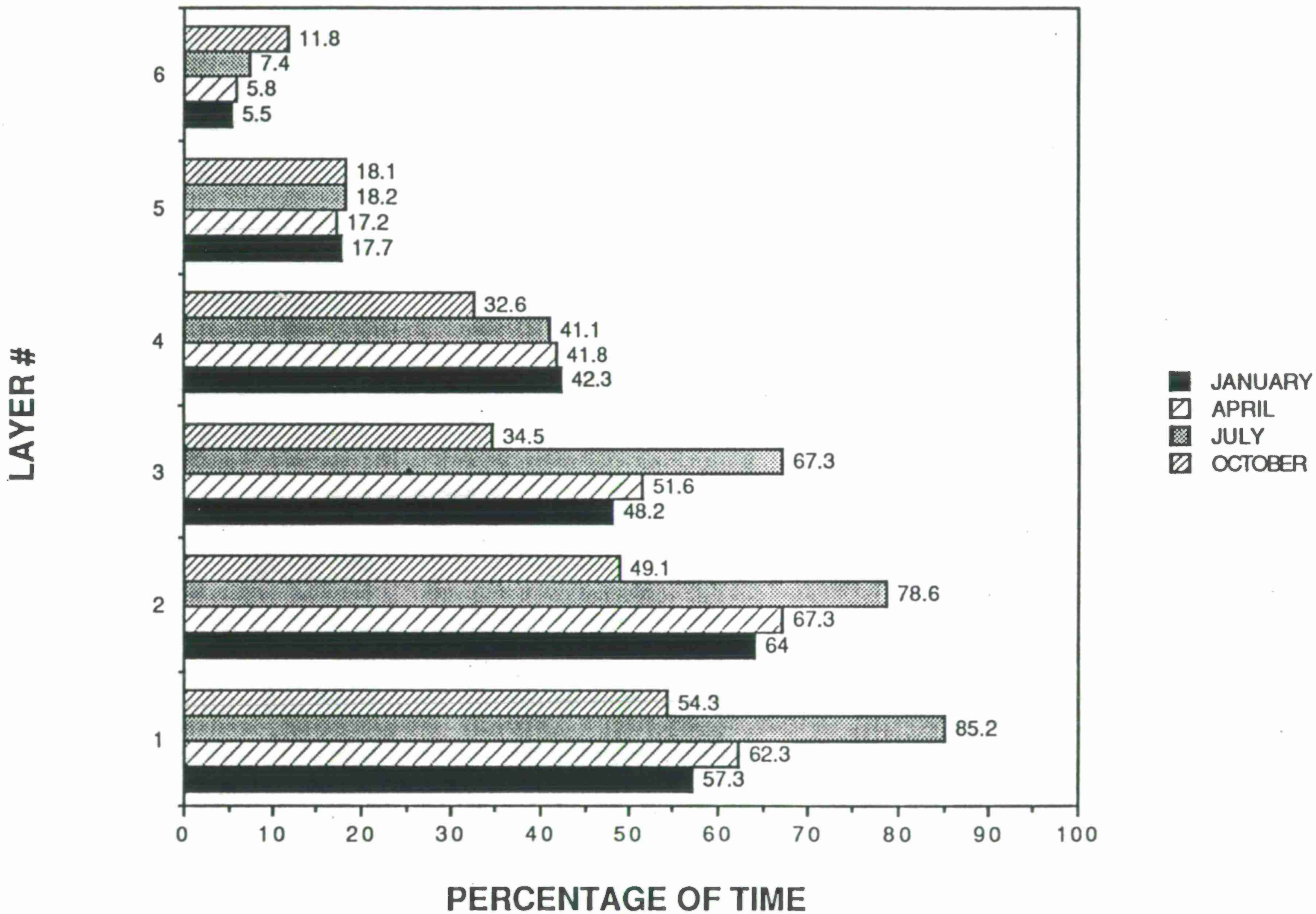
MEAN CLOUD PERCENT COMPARISON FOR 55.05 N 175.26 E (17)



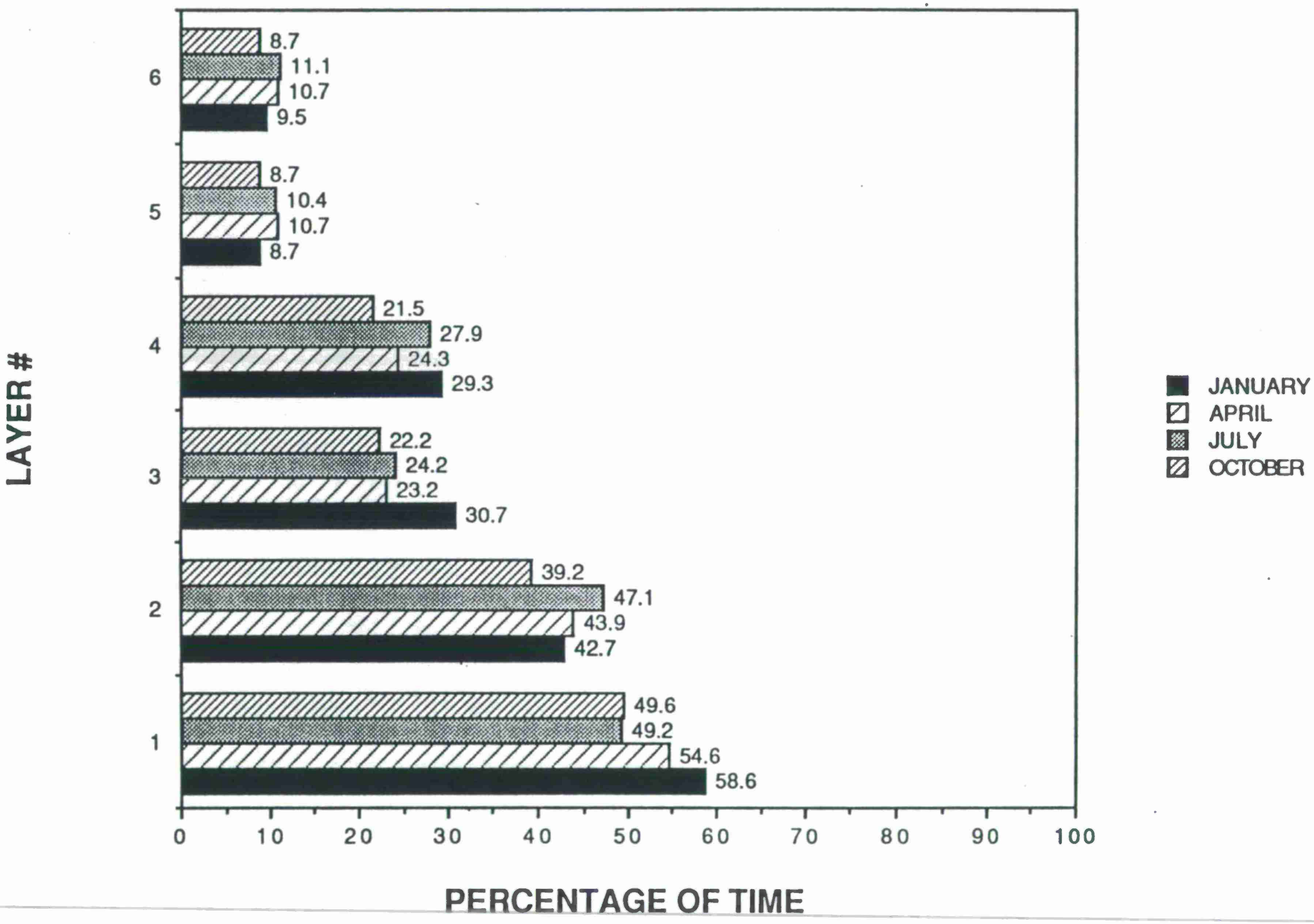

MEAN CLOUD PERCENT COMPARISON FOR 55.17 N 175.13 W (18)
LAYER #
PERCENTAGE OF TIME
6
5
4
3
2
1
4.8
3.1
4.4
5.6
8
10.2
8
7.6
18.3
25.4
24.3
22.9
19.4
32.8
25.7
24.3
36.7
48.3
44.4
36.9
57.9
45.2
60.8
54.6
0
10
20
30
40
50
60
70
80
90
100
JANUARY
APRIL
JULY
OCTOBER


MEAN CLOUD PERCENT COMPARISON FOR 55.17 N 164.87 W (19)
LAYER #
PERCENTAGE OF TIME
JANUARY
APRIL
JULY
OCTOBER
6
5
4
3
2
1
12.4
10.4
7.6
6.2
14.5
17.9
16
18.7
31.2
41.2
35.2
37.5
37.4
54.3
42.1
41.2
57.5
73.2
60.8
56.4
59
67.1
60.7
55.4
0
10
20
30
40
50
60
70
80
90
100

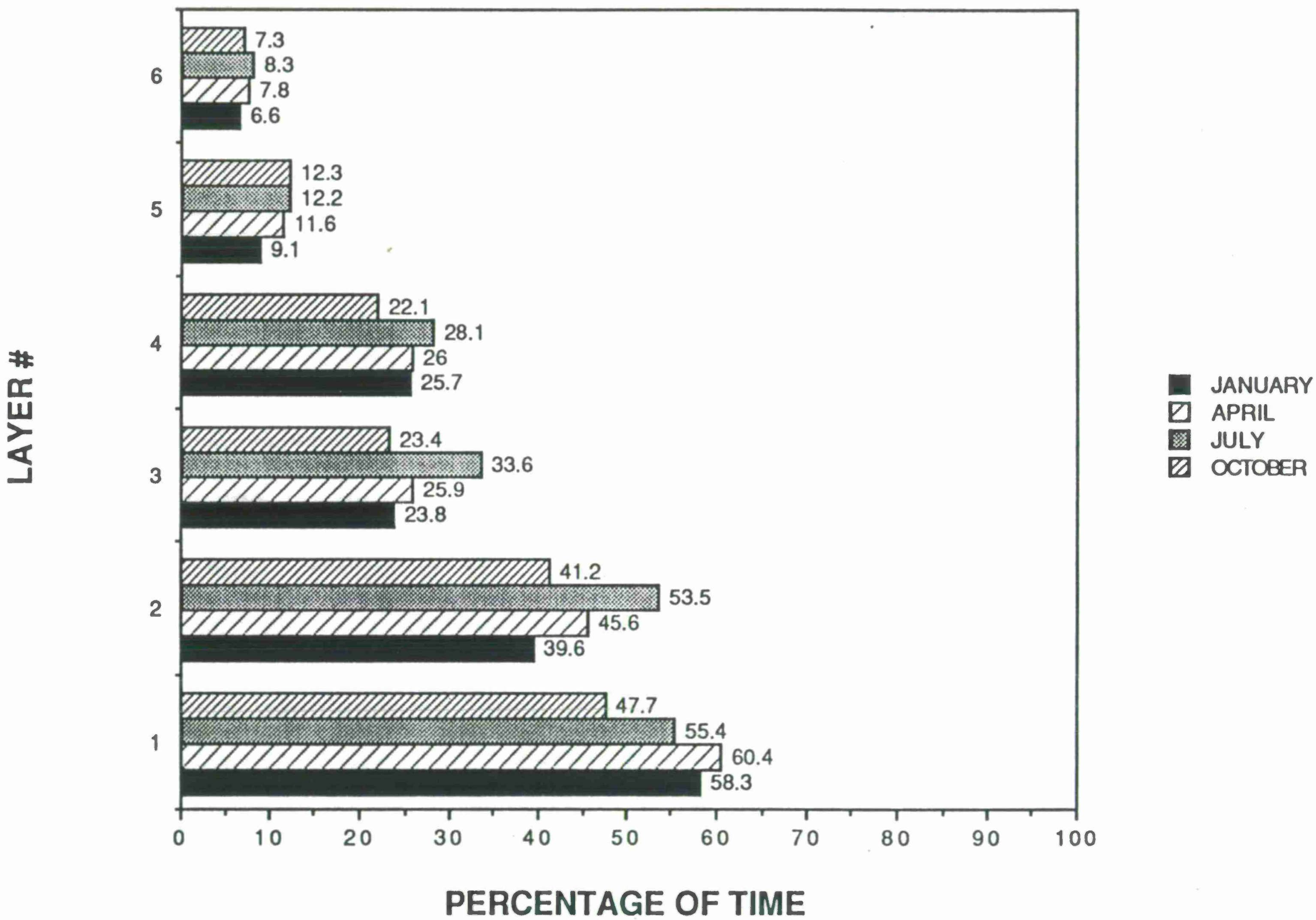
MEAN CLOUD PERCENT COMPARISON FOR 52.33 N 174.33 E (20)
(SHEMYA AFB)



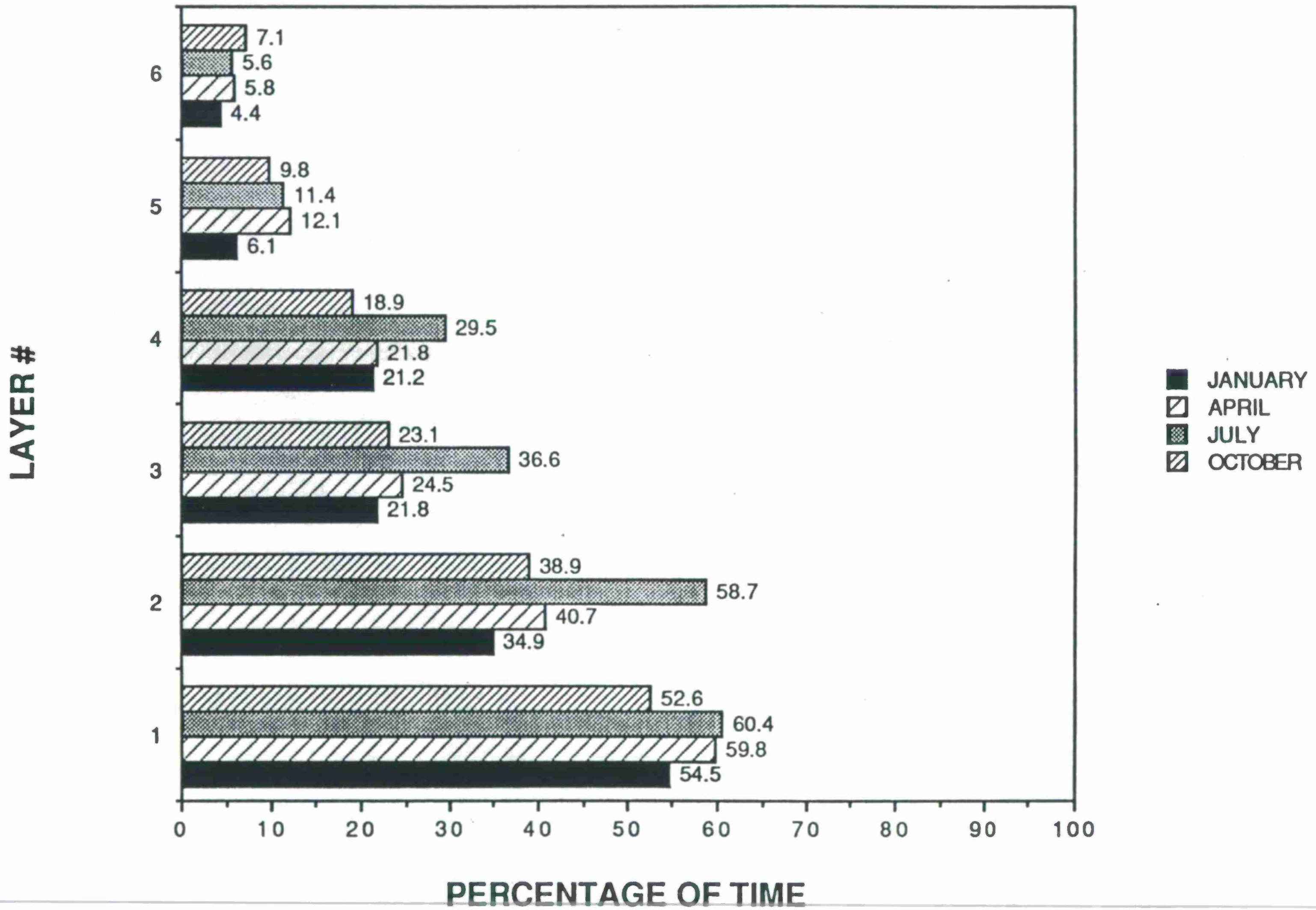
MEAN CLOUD PERCENT COMPARISON FOR 49.98 N 160.33 E (22)



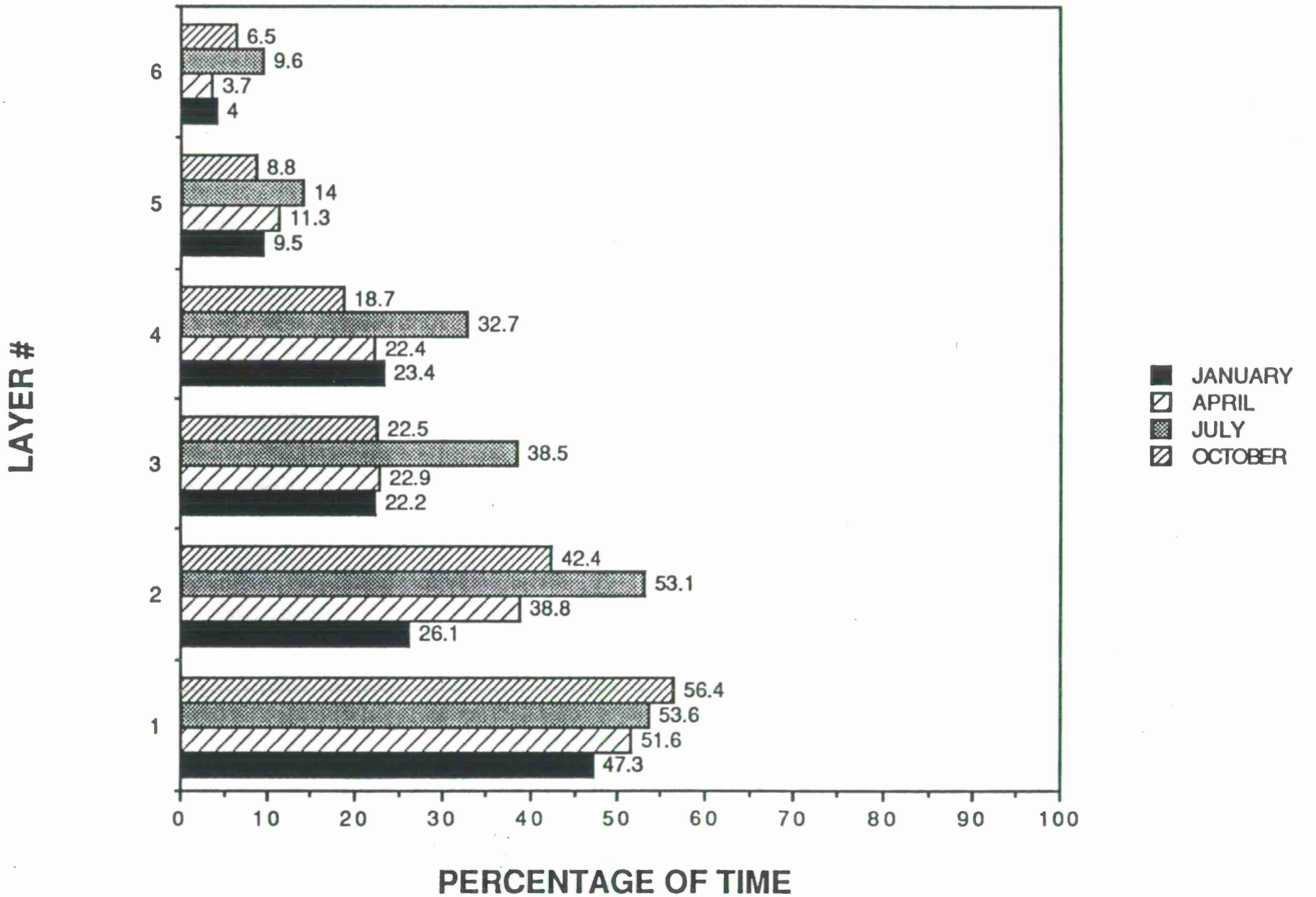
MEAN CLOUD PERCENT COMPARISON FOR 50.16 N 169.96 E (23)



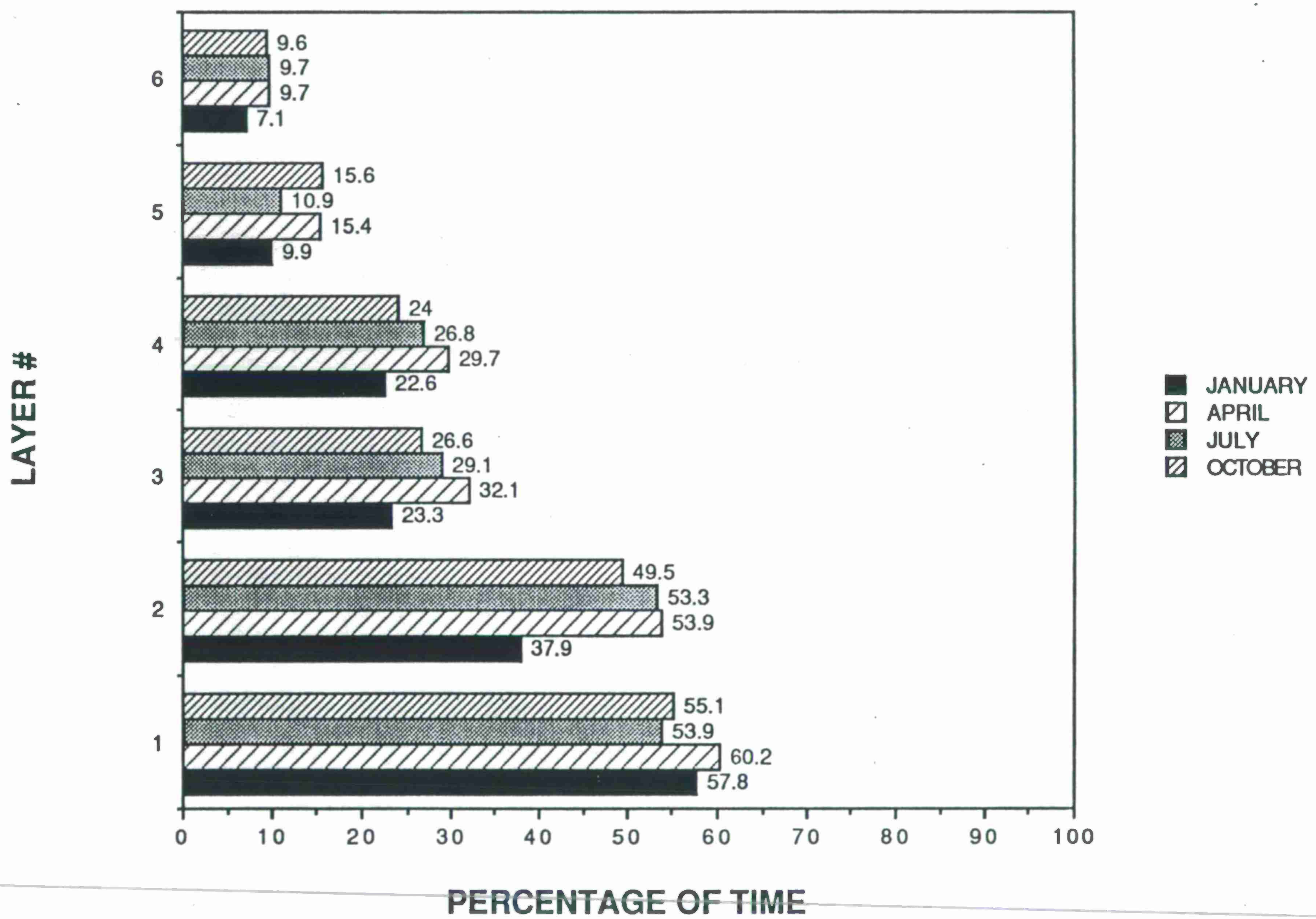
MEAN CLOUD PERCENT COMPARISON FOR 50.18 N 179.91 E (24)



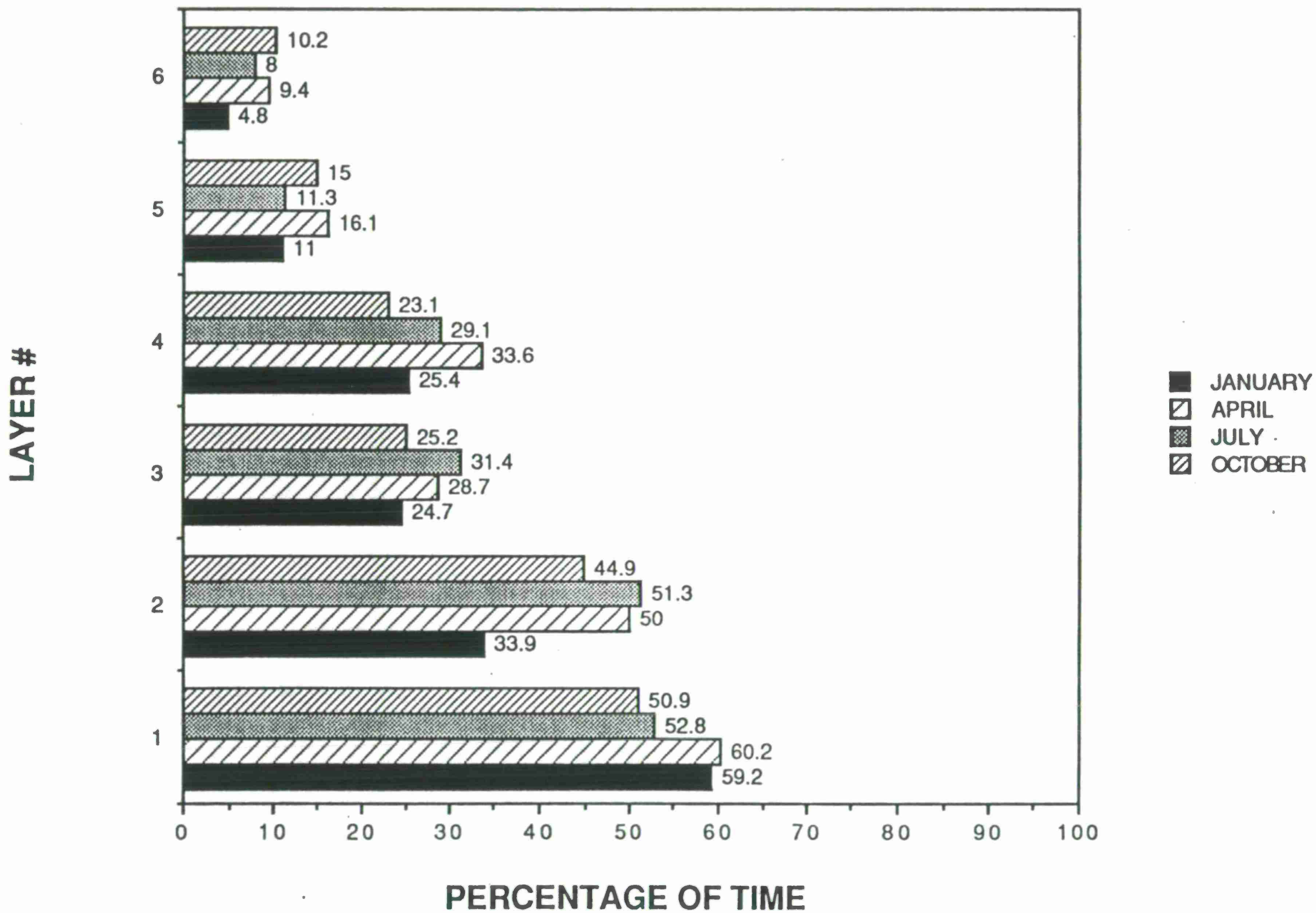
MEAN CLOUD PERCENT COMPARISON FOR 49.94 N 170.00 W (25)



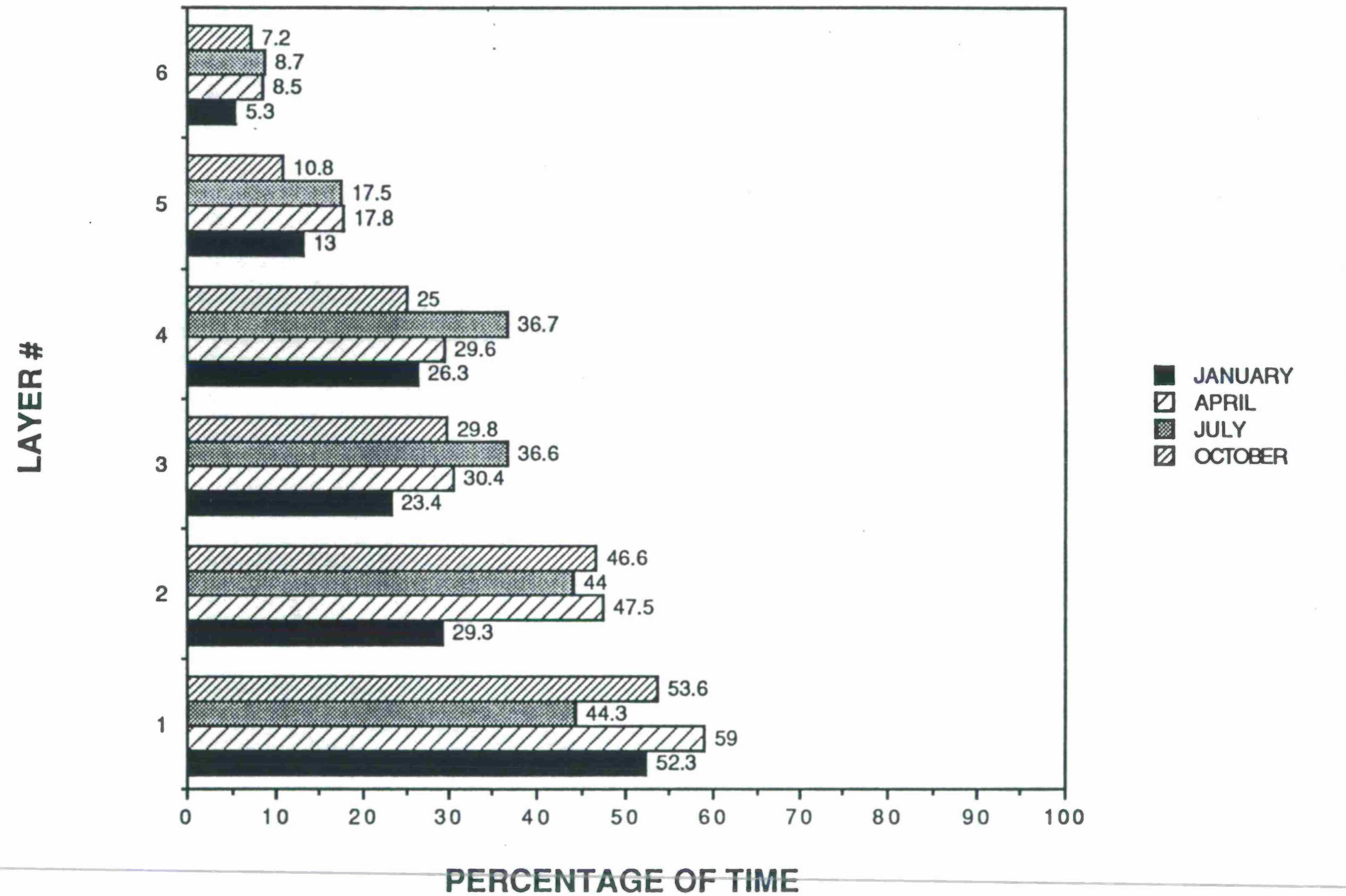
MEAN CLOUD PERCENT COMPARISON FOR 44.85 N 164.92 E (28)



MEAN CLOUD PERCENT COMPARISON FOR 44.93 N 174.89 E (29)



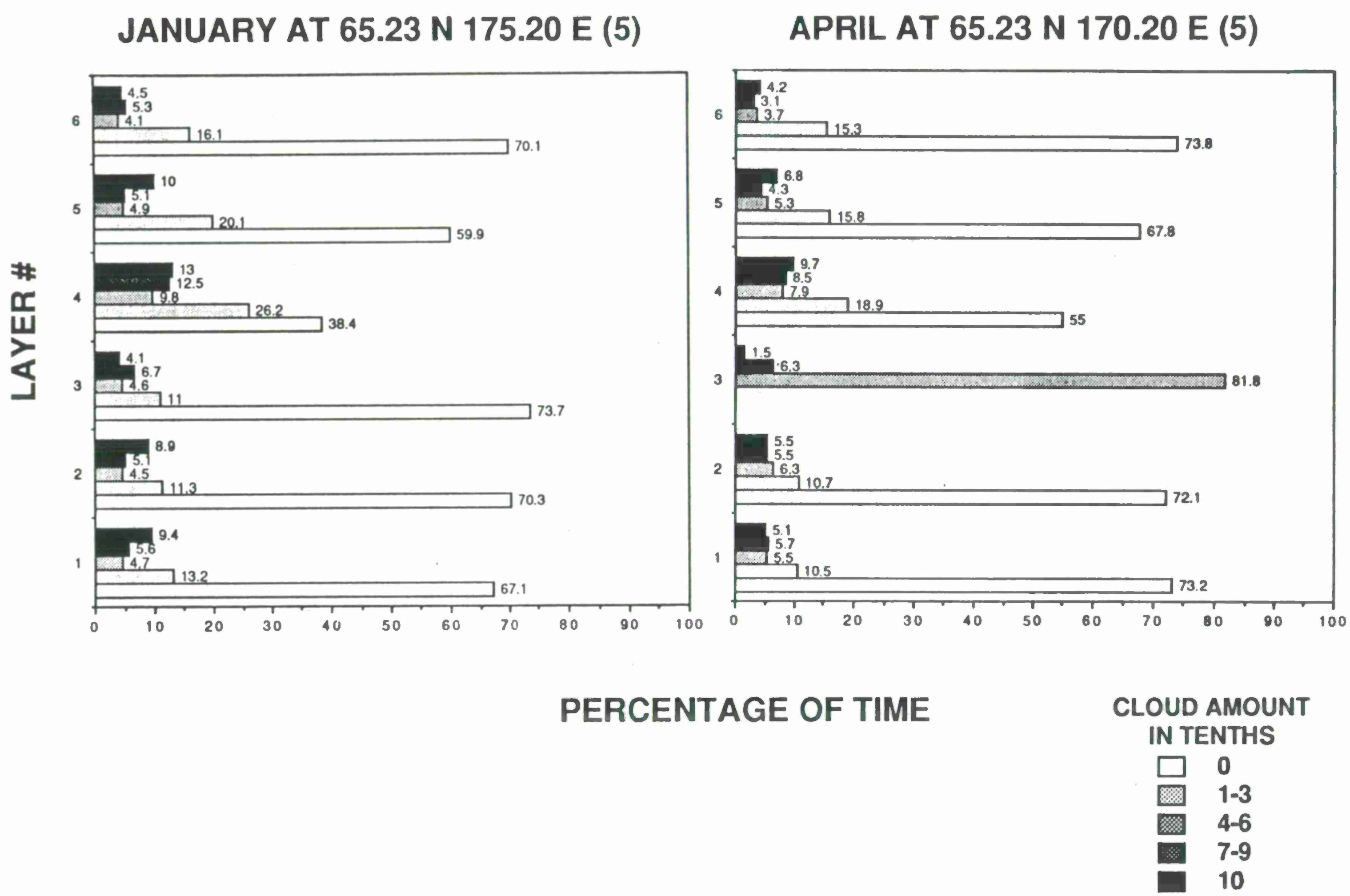
MEAN CLOUD PERCENT COMPARISON FOR 45.00 N 174.99 W (30)

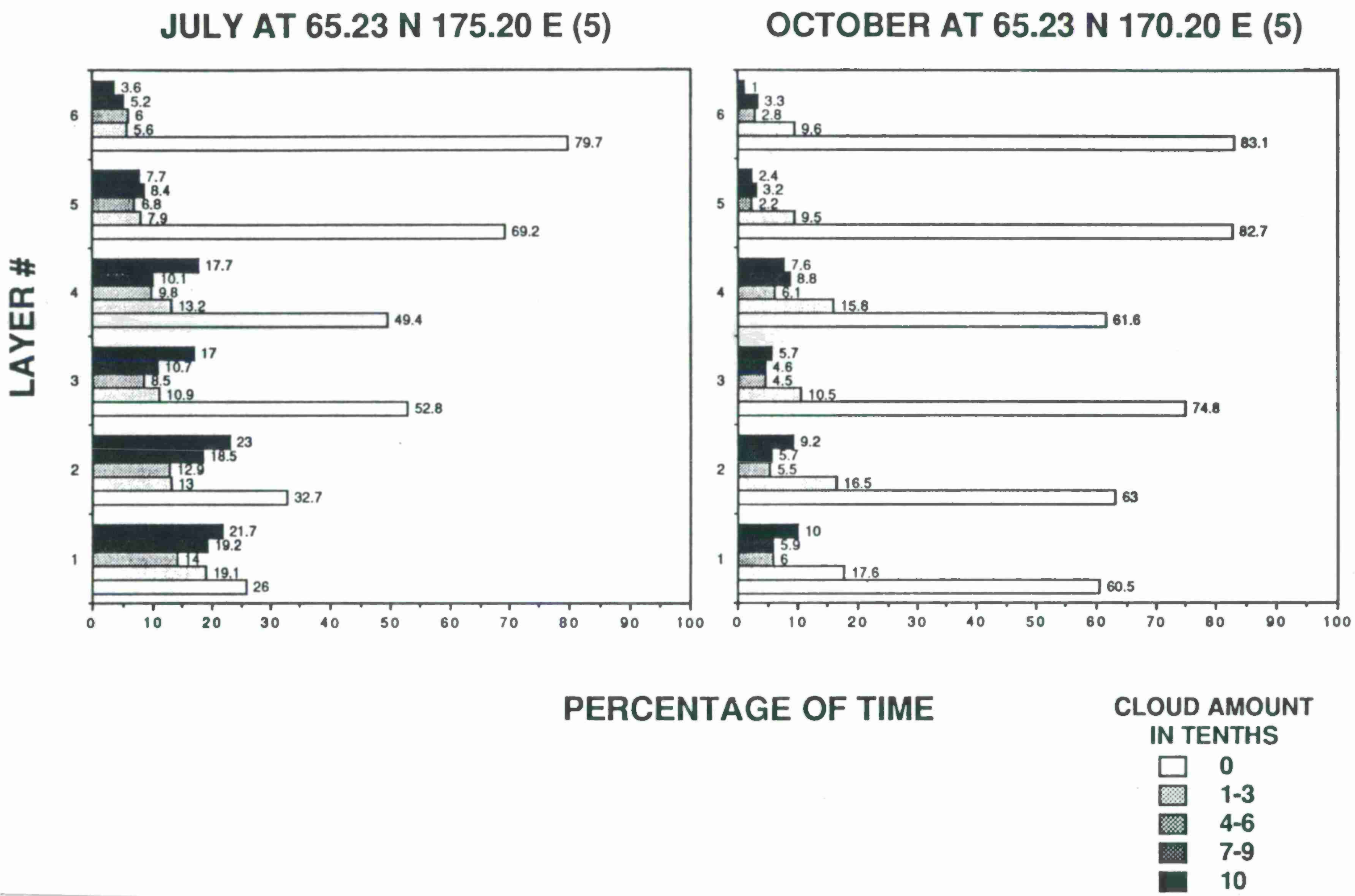


APPENDIX B

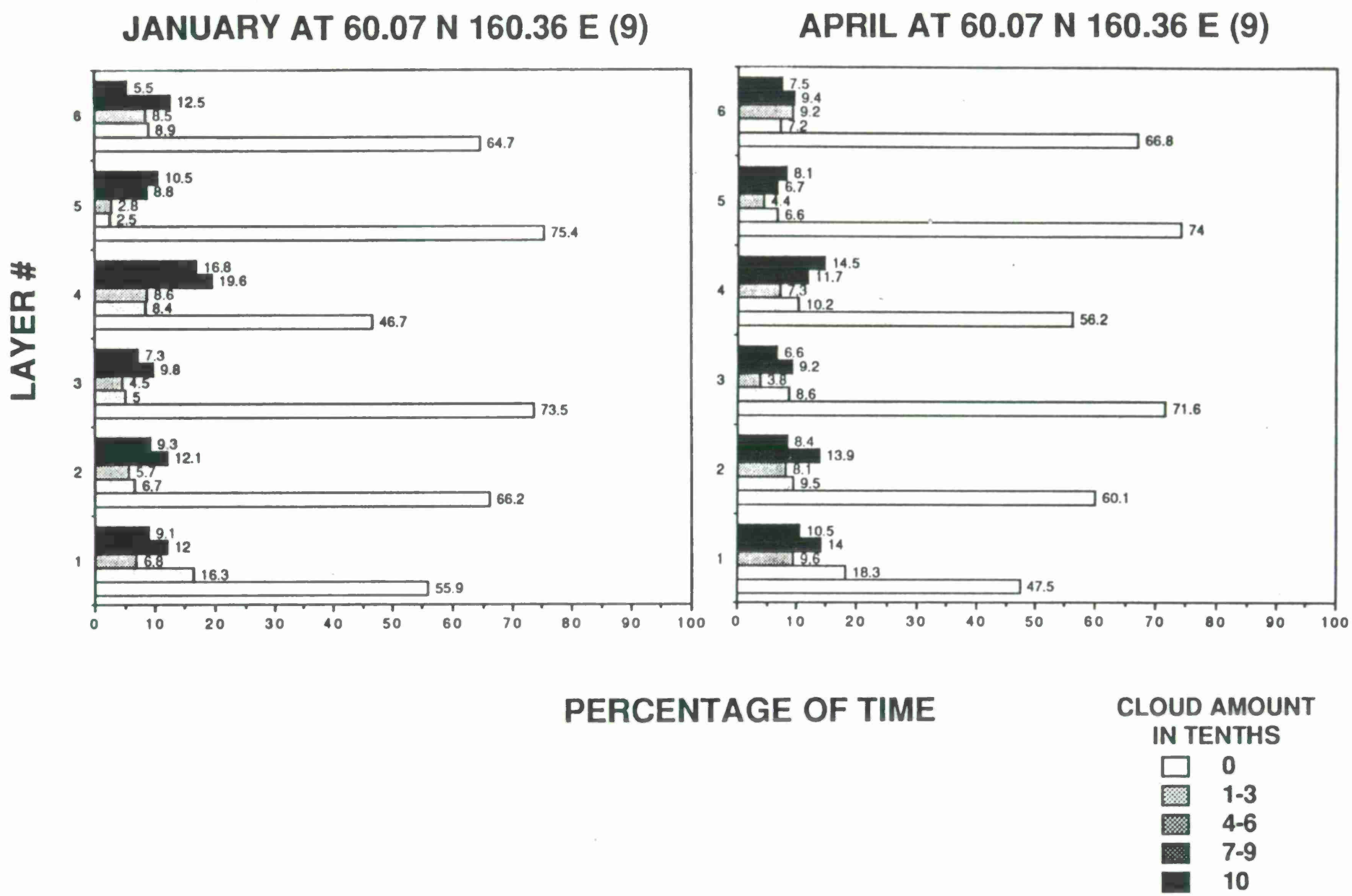
PERCENT FREQUENCY OF CLOUD AMOUNT STATISTICS

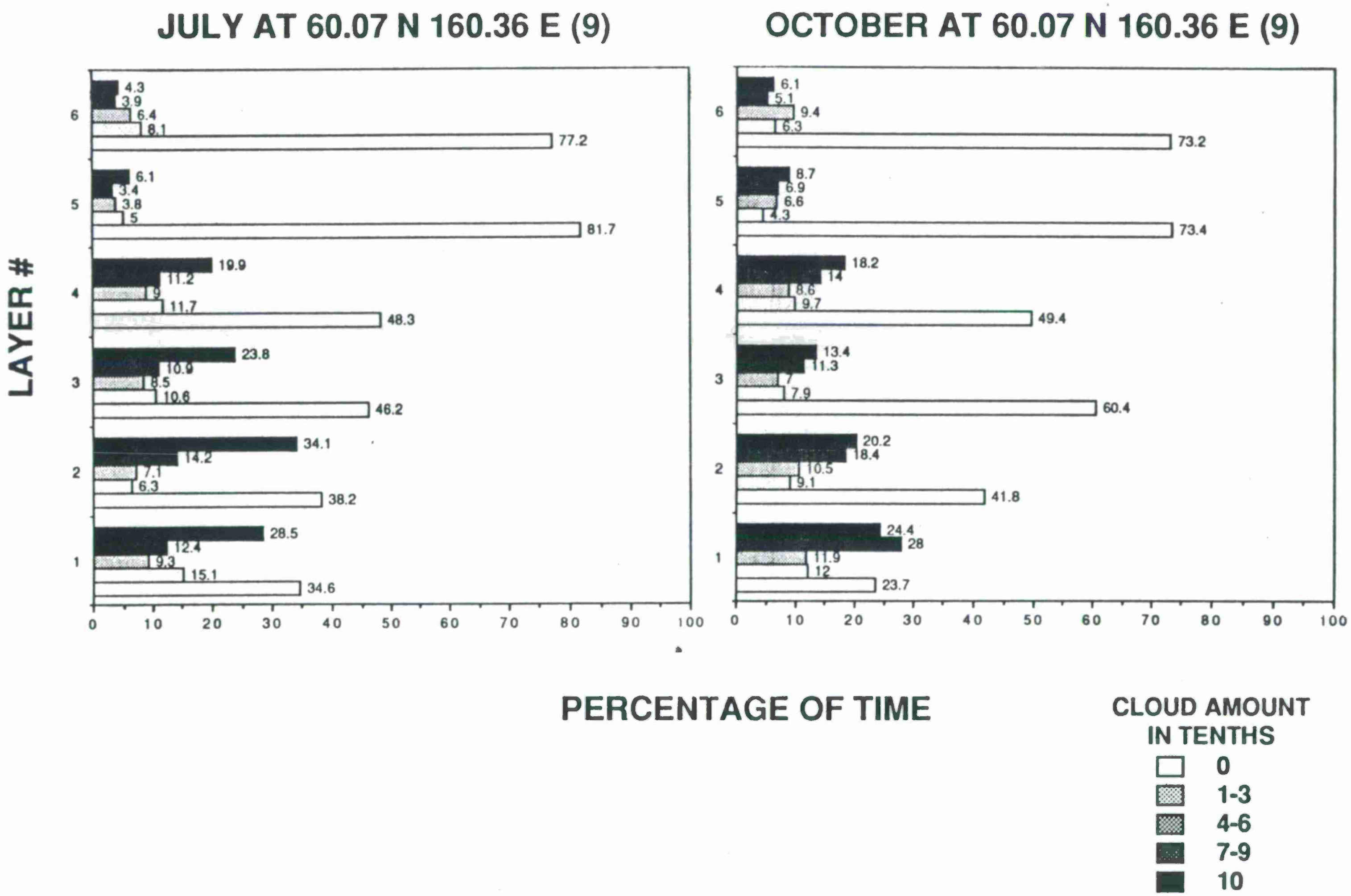
(January, April, July, October)

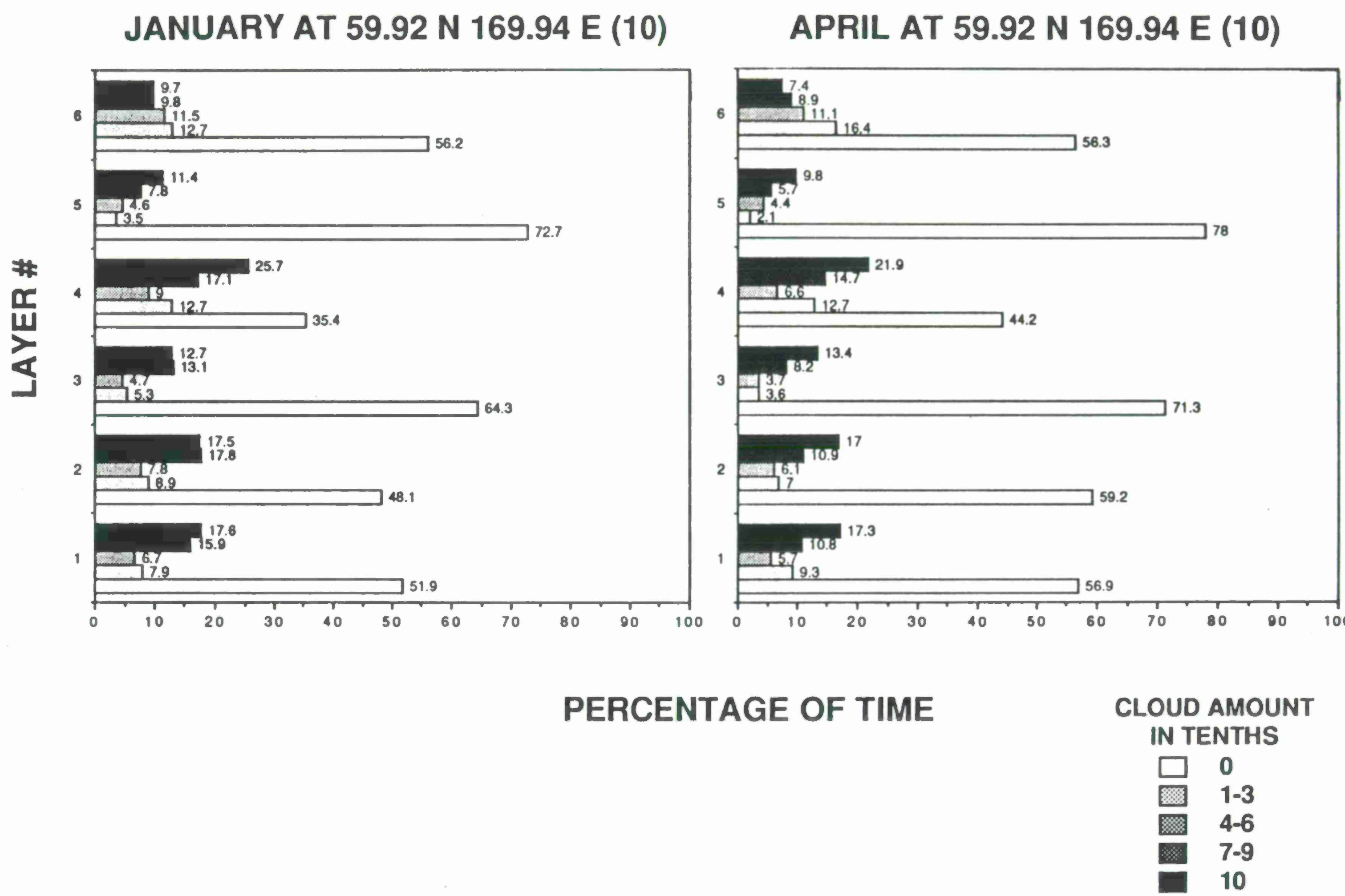

JANUARY AT 65.23 N 175.20 E (5)
APRIL AT 65.23 N 170.20 E (5)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10



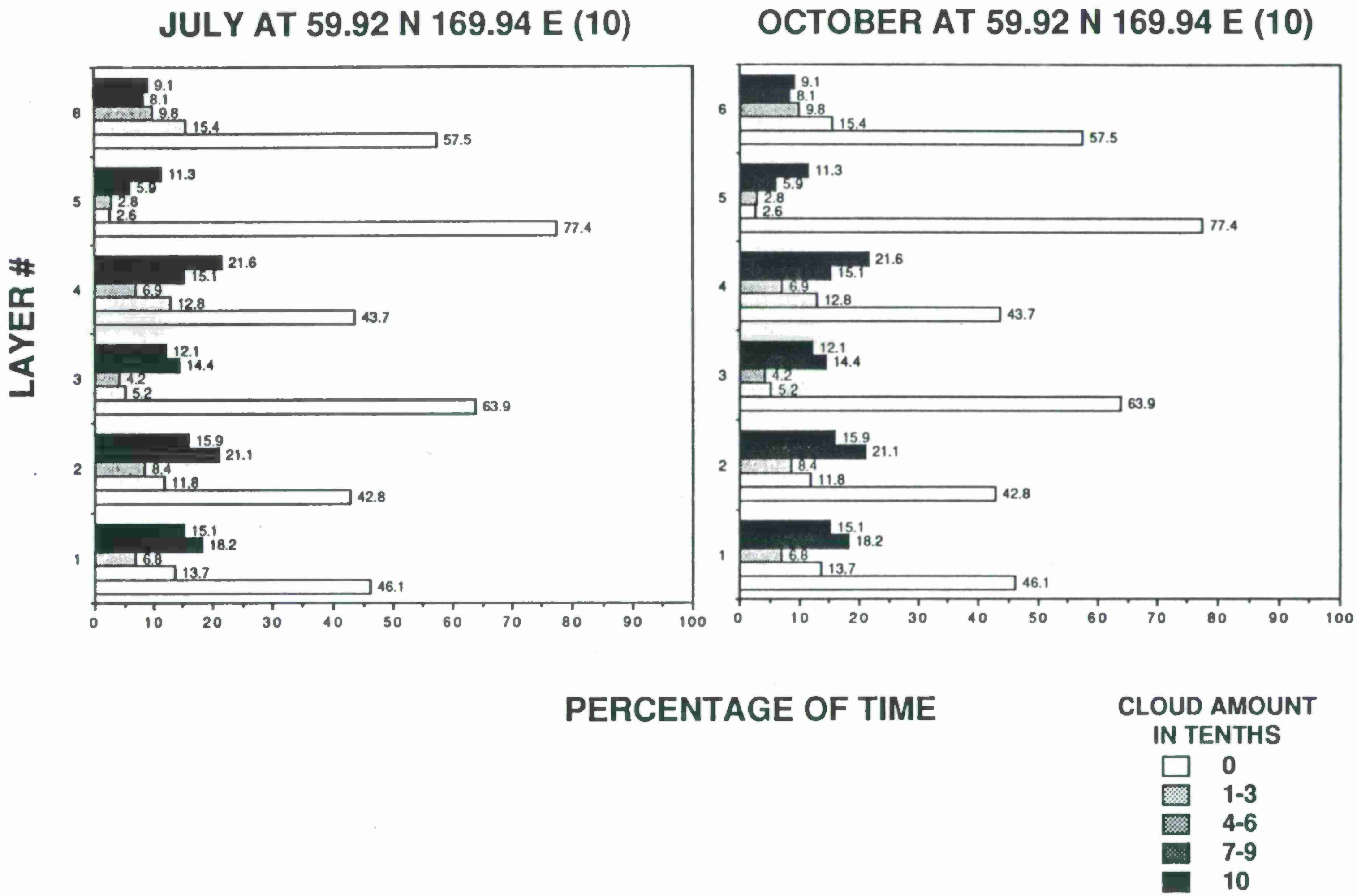
JULY AT 65.23 N 175.20 E (5)
OCTOBER AT 65.23 N 170.20 E (5)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10


JANUARY AT 60.07 N 160.36 E (9)
APRIL AT 60.07 N 160.36 E (9)
LAYER #
6
5.5
12.5
8.5
8.9
64.7
5
10.5
8.8
2.8
2.5
75.4
4
16.8
19.6
8.6
8.4
46.7
3
7.3
9.8
4.5
5
73.5
2
9.3
12.1
5.7
6.7
66.2
1
9.1
12
6.8
16.3
55.9
0 10 20 30 40 50 60 70 80 90 100
6
7.5
9.4
9.2
7.2
66.8
5
8.1
6.7
4.4
6.6
74
4
14.5
11.7
7.3
10.2
56.2
3
6.6
9.2
3.8
8.6
71.6
2
8.4
13.9
8.1
9.5
60.1
1
10.5
14
9.6
18.3
47.5
0 10 20 30 40 50 60 70 80 90 100
PERCENTAGE OF TIME
CLOUD AMOUNT
IN TENTHS
0
1-3
4-6
7-9
10

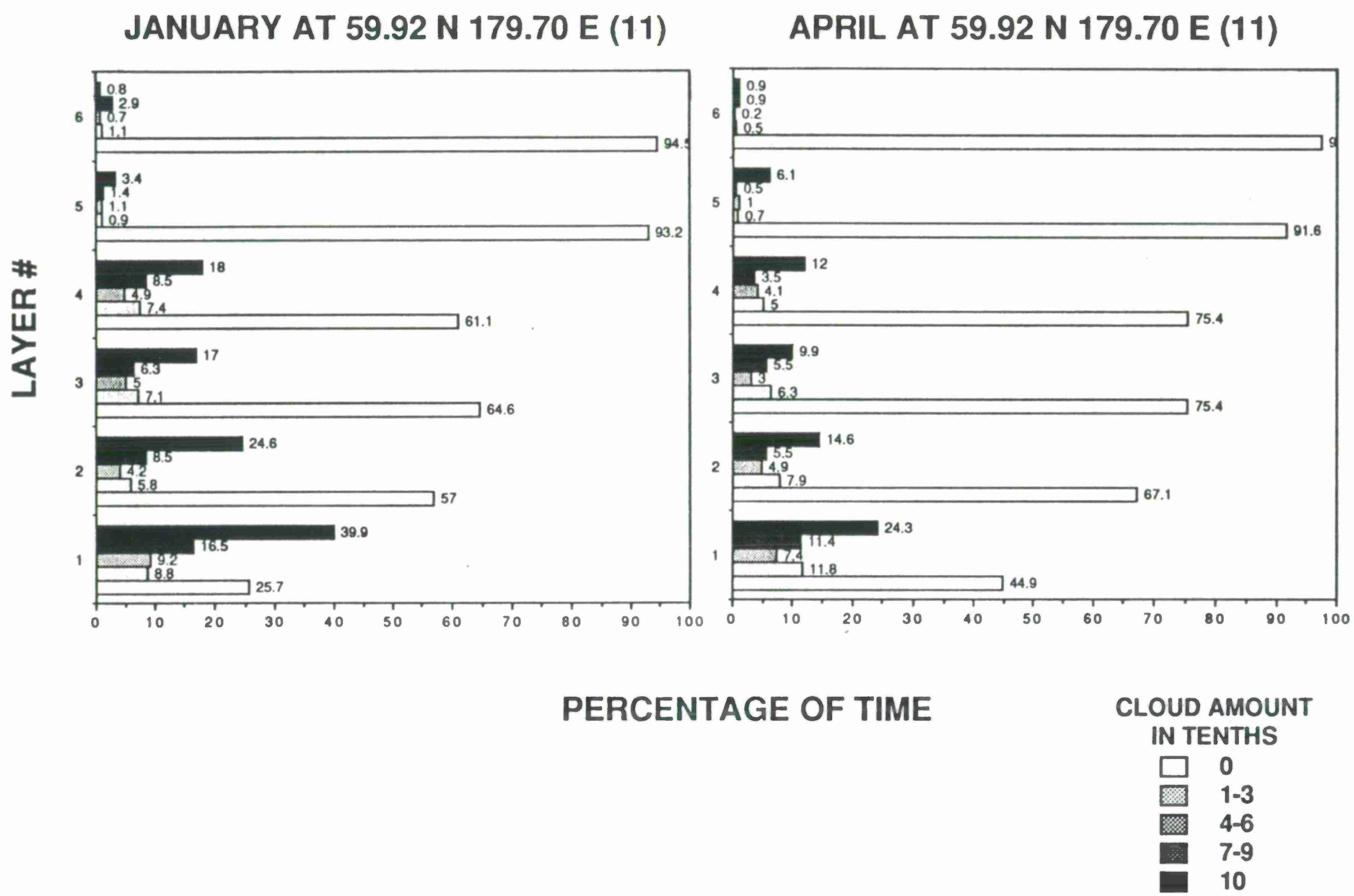

JULY AT 60.07 N 160.36 E (9)
OCTOBER AT 60.07 N 160.36 E (9)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

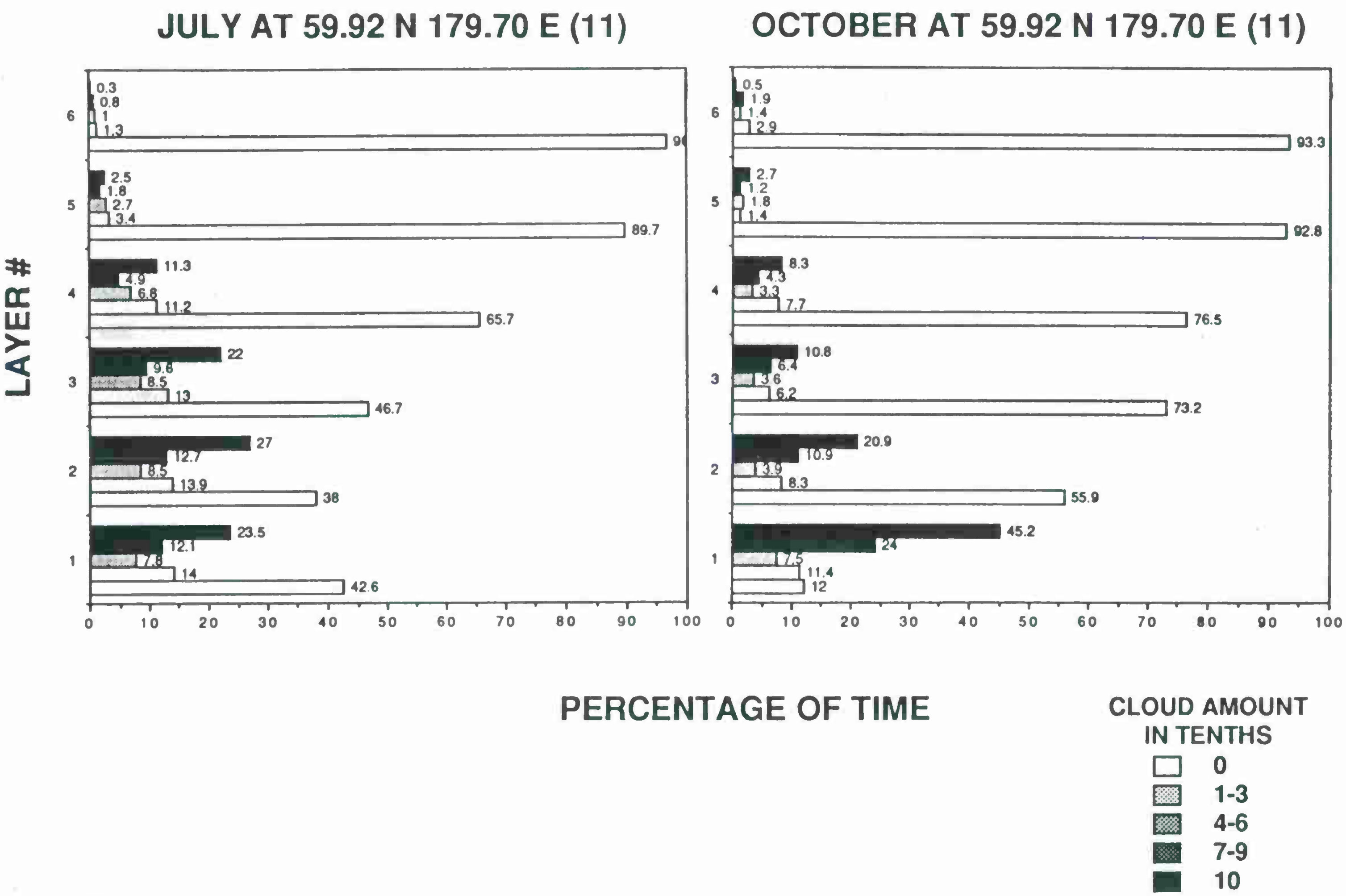


JANUARY AT 59.92 N 169.94 E (10)
APRIL AT 59.92 N 169.94 E (10)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

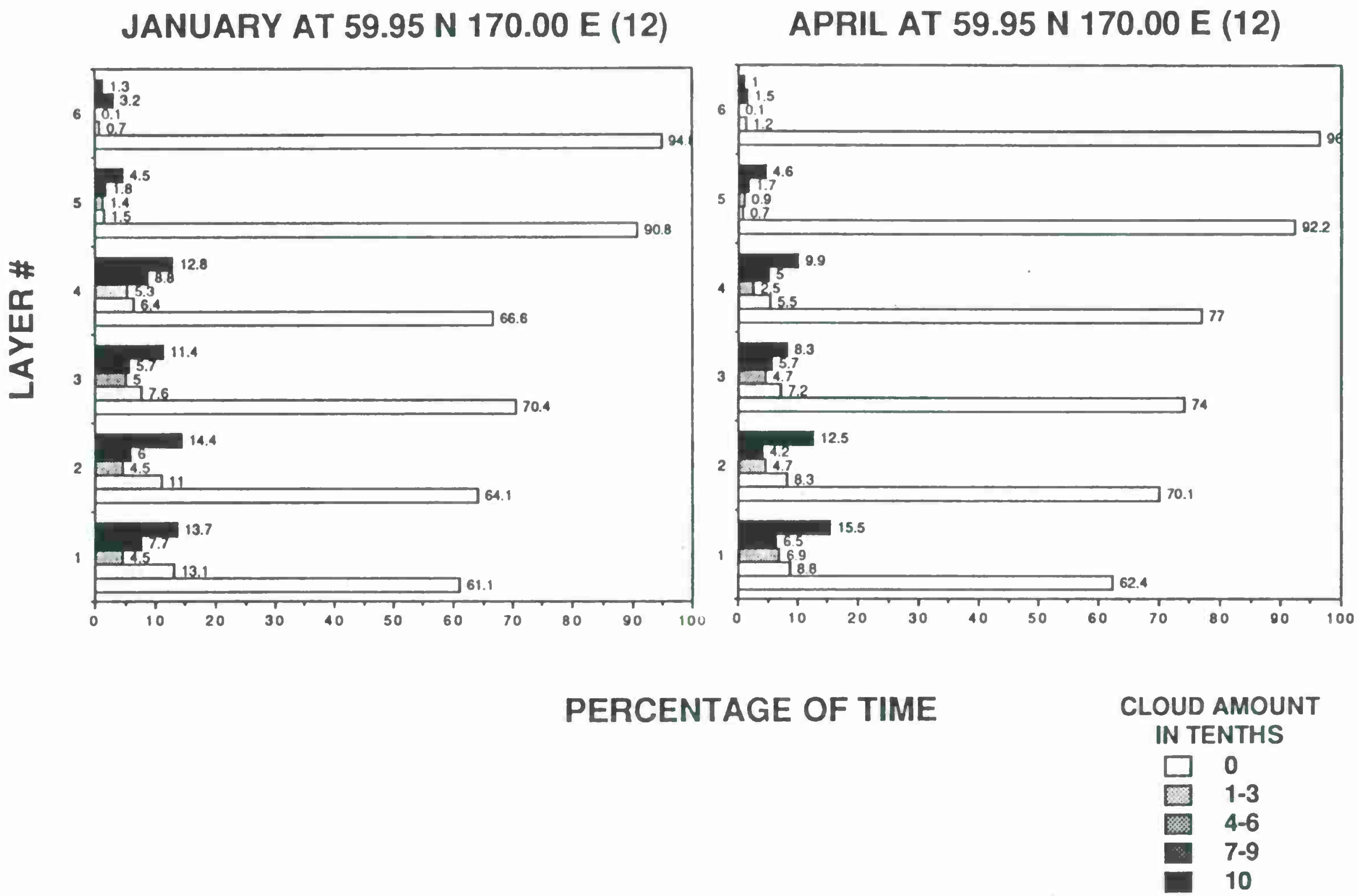


JULY AT 59.92 N 169.94 E (10)
OCTOBER AT 59.92 N 169.94 E (10)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

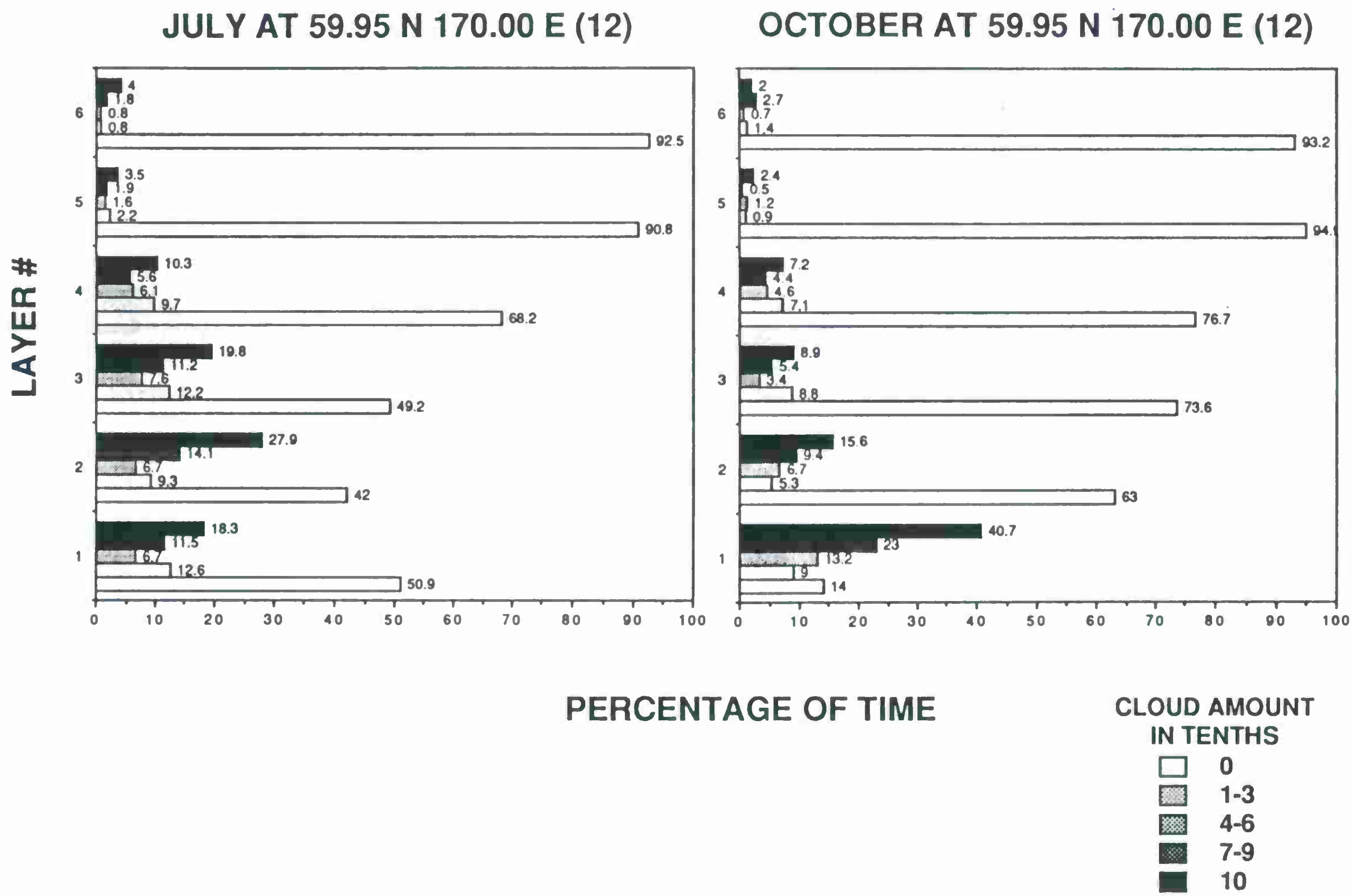

JANUARY AT 59.92 N 179.70 E (11)
APRIL AT 59.92 N 179.70 E (11)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

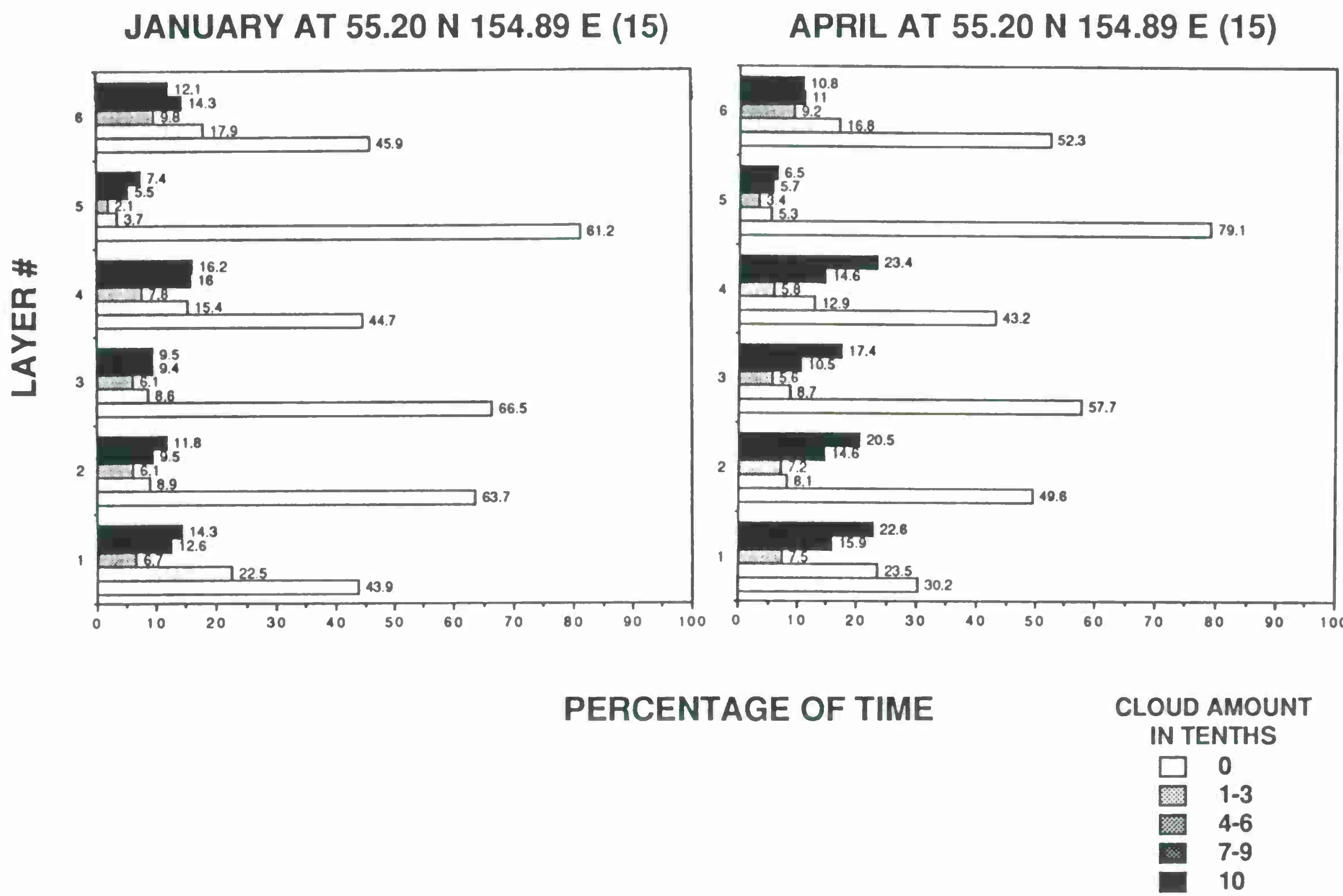


JULY AT 59.92 N 179.70 E (11)
OCTOBER AT 59.92 N 179.70 E (11)
LAYER #
6
5
4
3
2
1
0.3
0.8
1
1.3
2.5
1.8
2.7
3.4
89.7
11.3
4.9
6.8
11.2
65.7
22
9.6
8.5
13
46.7
27
12.7
8.5
13.9
38
23.5
12.1
7.8
14
42.6
0.5
1.9
1.4
2.9
93.3
2.7
1.2
1.8
1.4
92.8
8.3
4.3
3.3
7.7
76.5
10.8
6.4
3.6
6.2
73.2
20.9
10.9
3.9
8.3
55.9
45.2
24
7.5
11.4
12
0 10 20 30 40 50 60 70 80 90 100
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

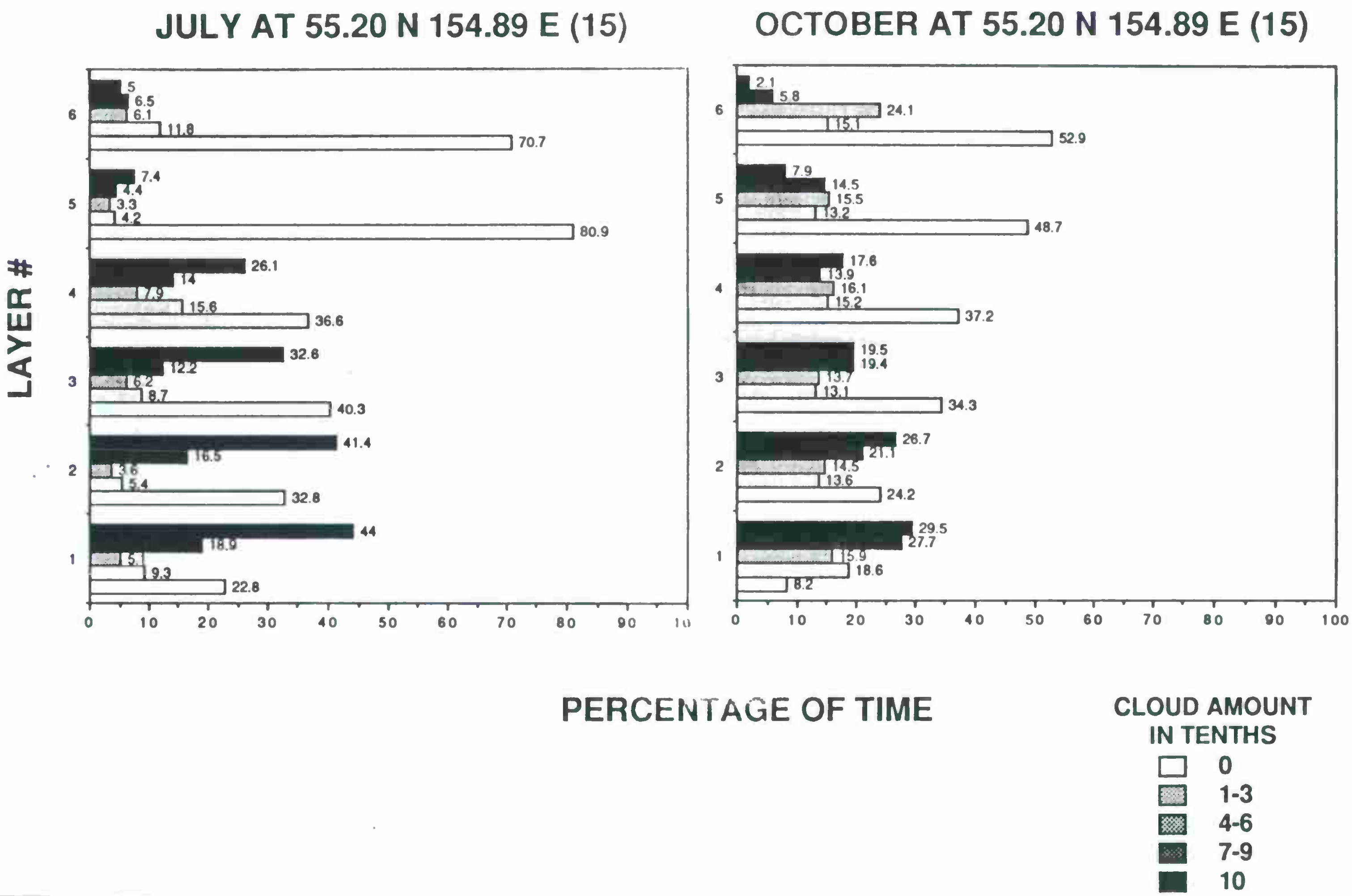


JANUARY AT 59.95 N 170.00 E (12)
APRIL AT 59.95 N 170.00 E (12)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10


JULY AT 59.95 N 170.00 E (12)
OCTOBER AT 59.95 N 170.00 E (12)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

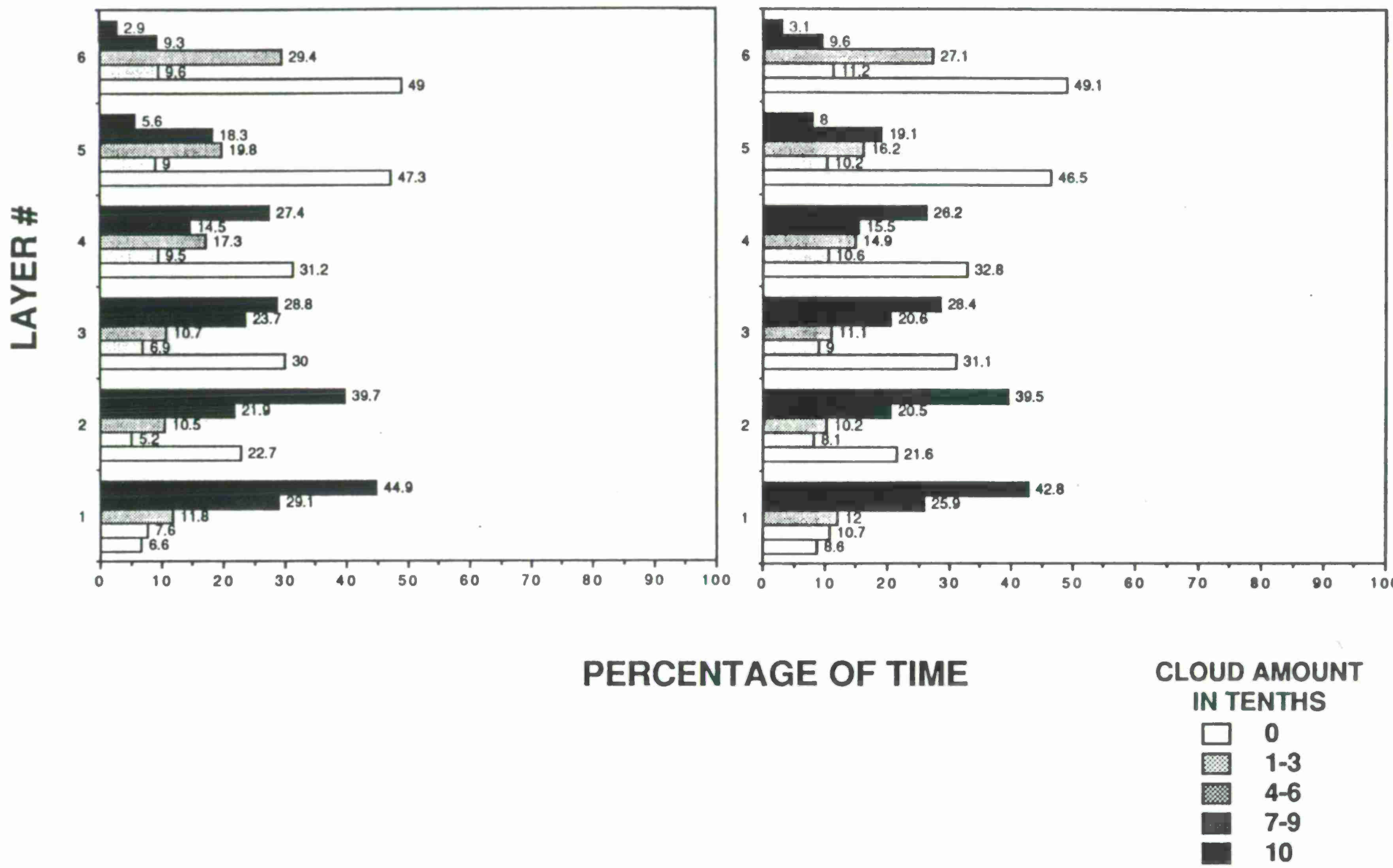


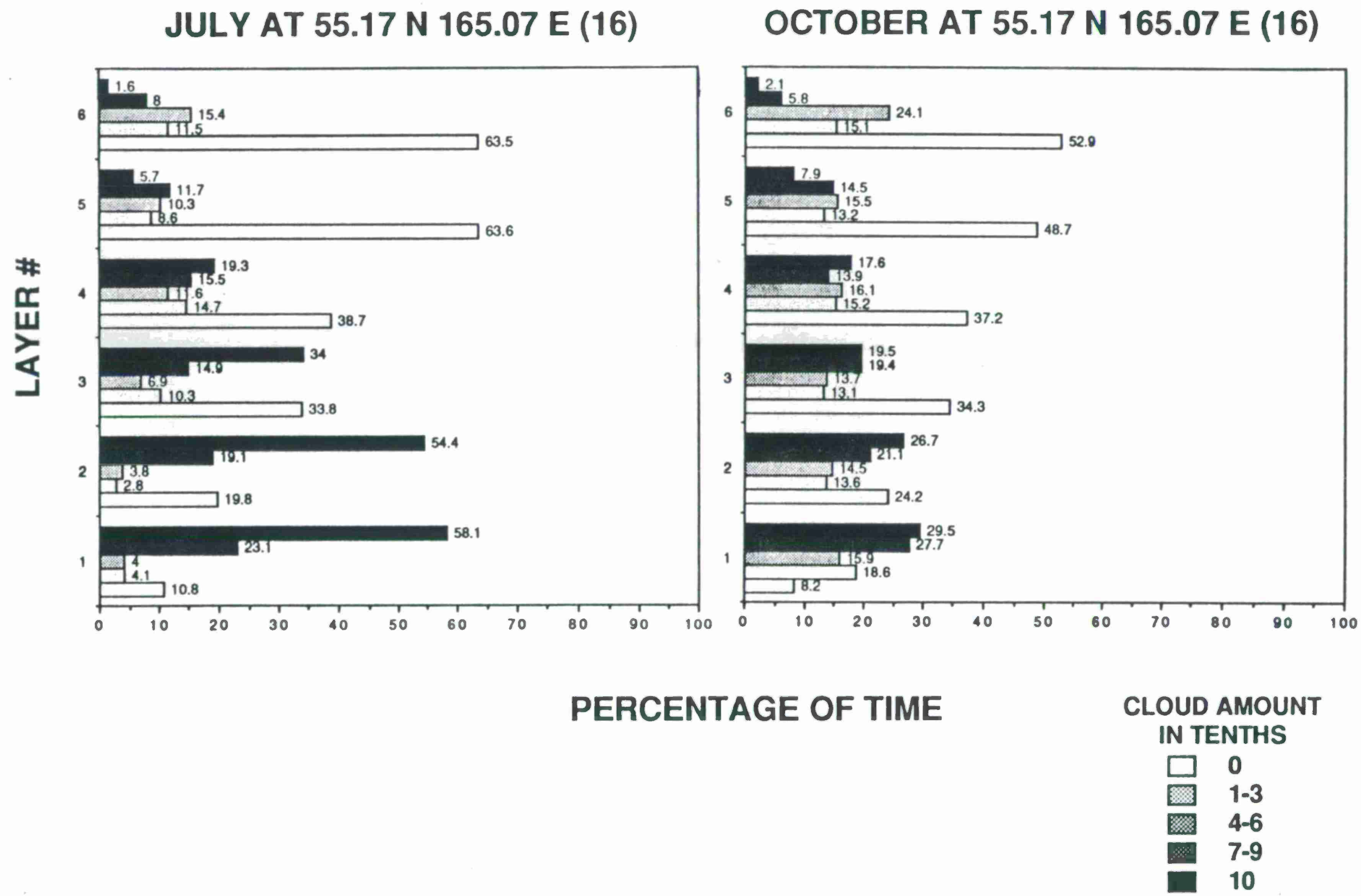
JANUARY AT 55.20 N 154.89 E (15)
APRIL AT 55.20 N 154.89 E (15)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10



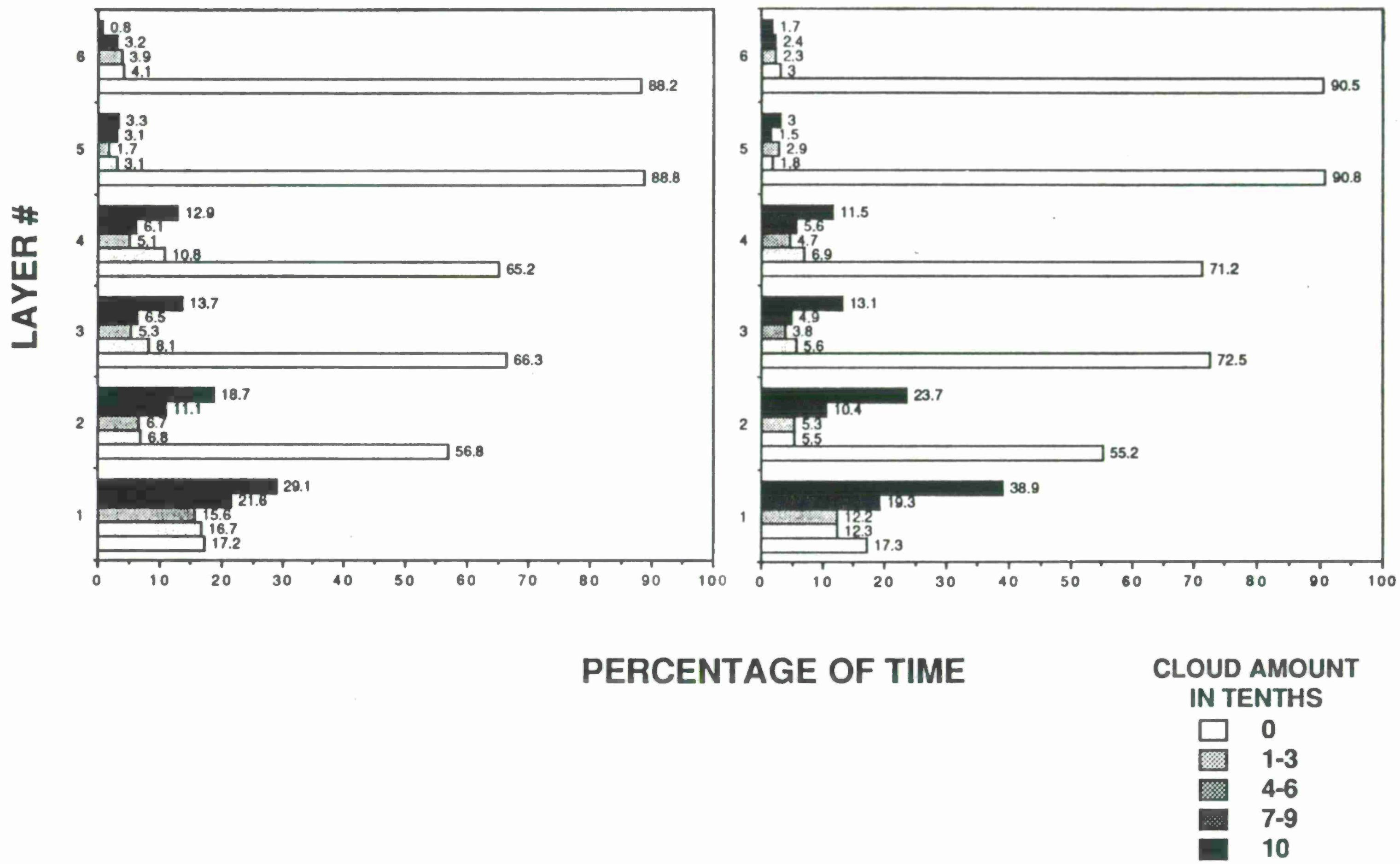
JULY AT 55.20 N 154.89 E (15)
OCTOBER AT 55.20 N 154.89 E (15)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

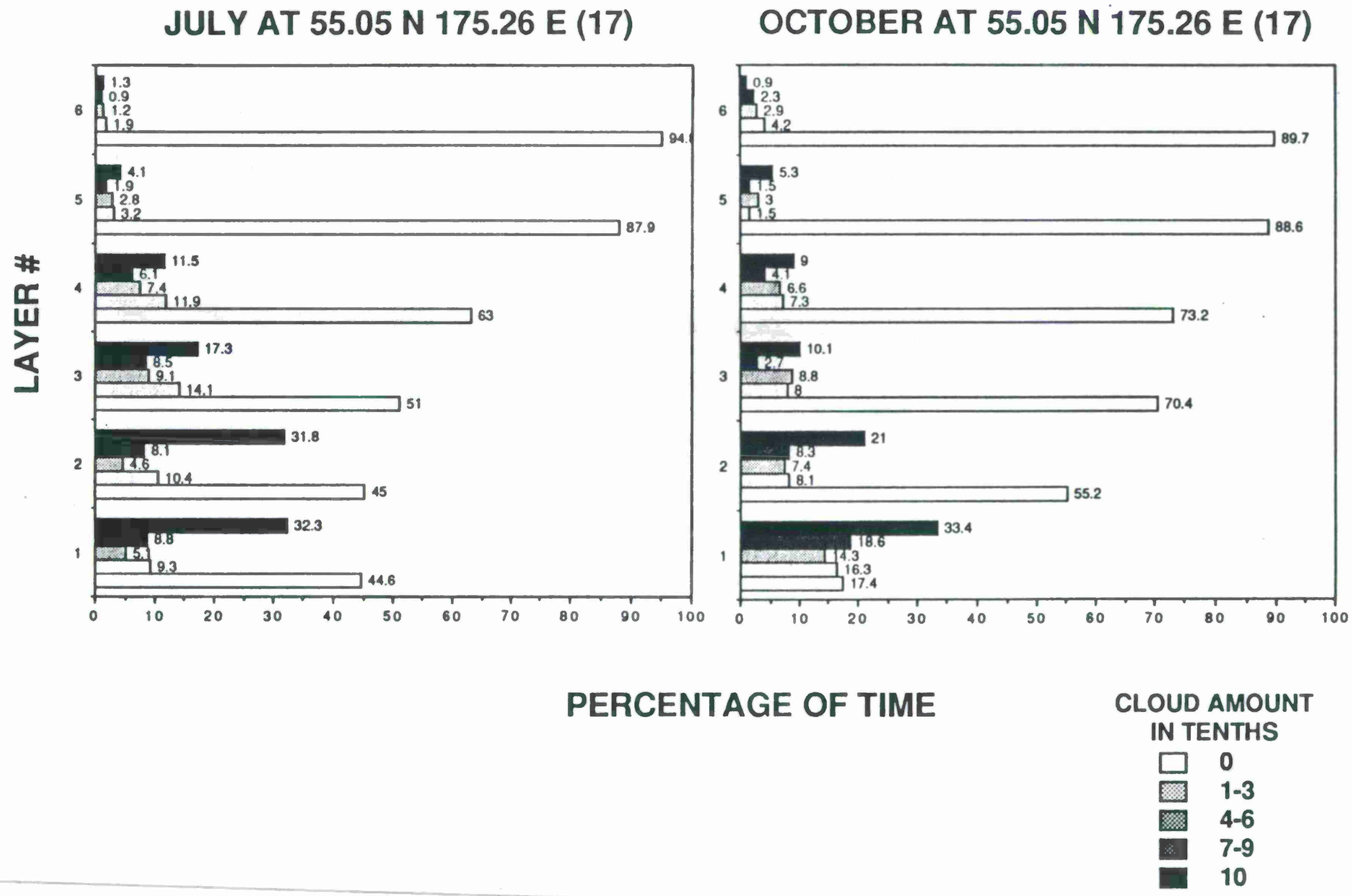
JANUARY AT 55.17 N 165.07 E (16)   APRIL AT 55.17 N 165.07 E (16)

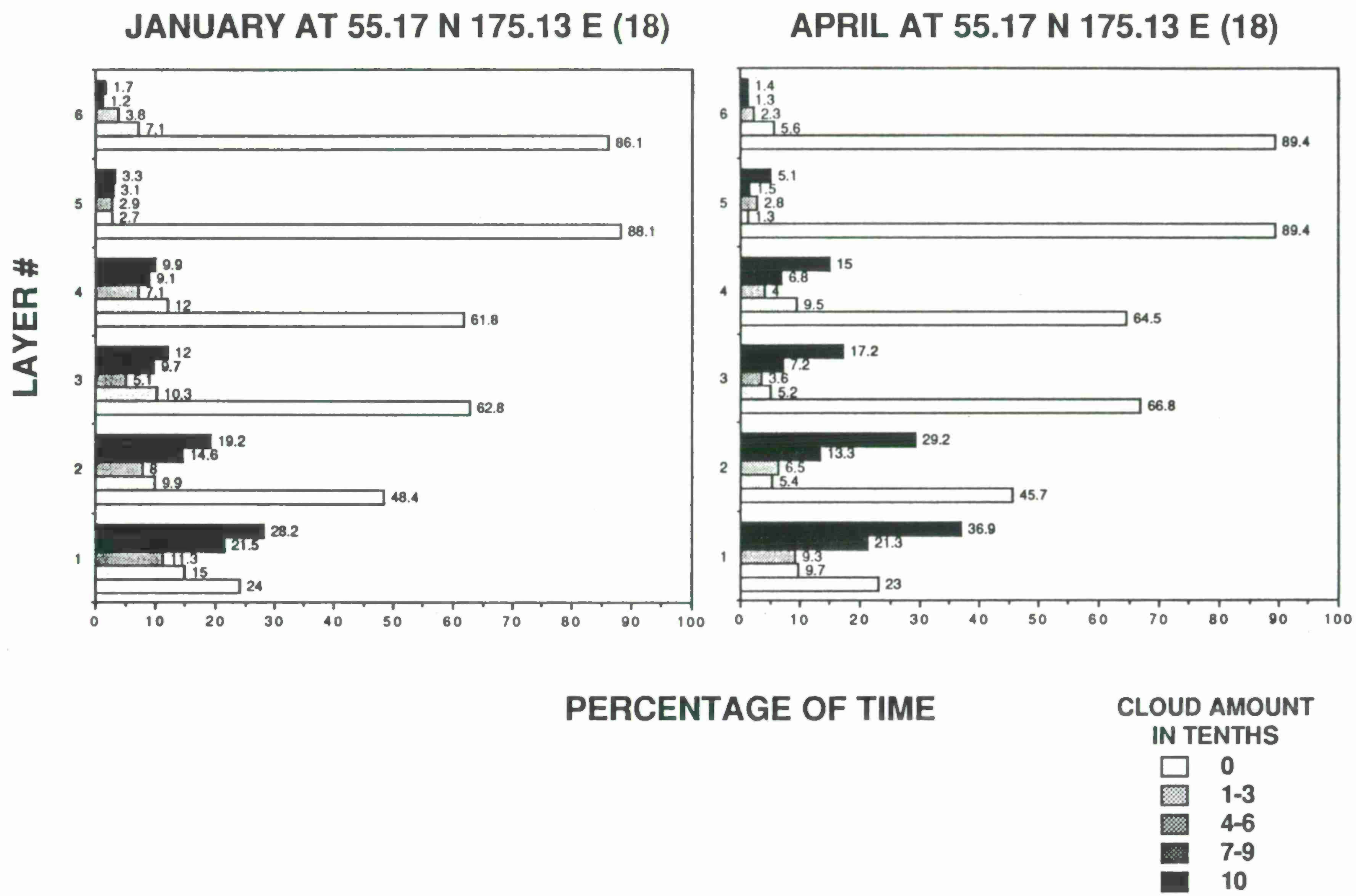



JULY AT 55.17 N 165.07 E (16)
OCTOBER AT 55.17 N 165.07 E (16)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

JANUARY AT 55.05 N 175.26 E (17) APRIL AT 55.05 N 175.26 E (17)

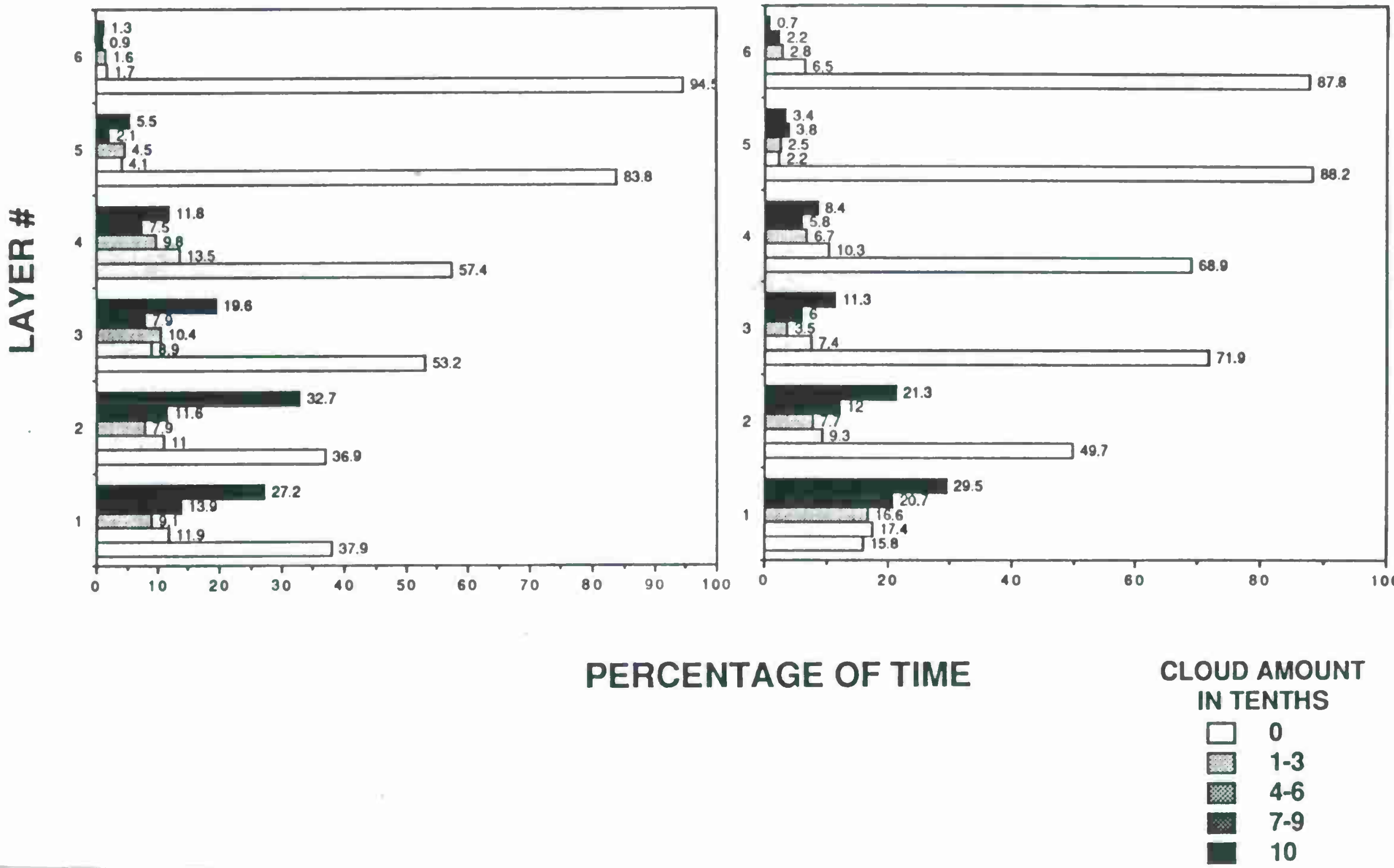


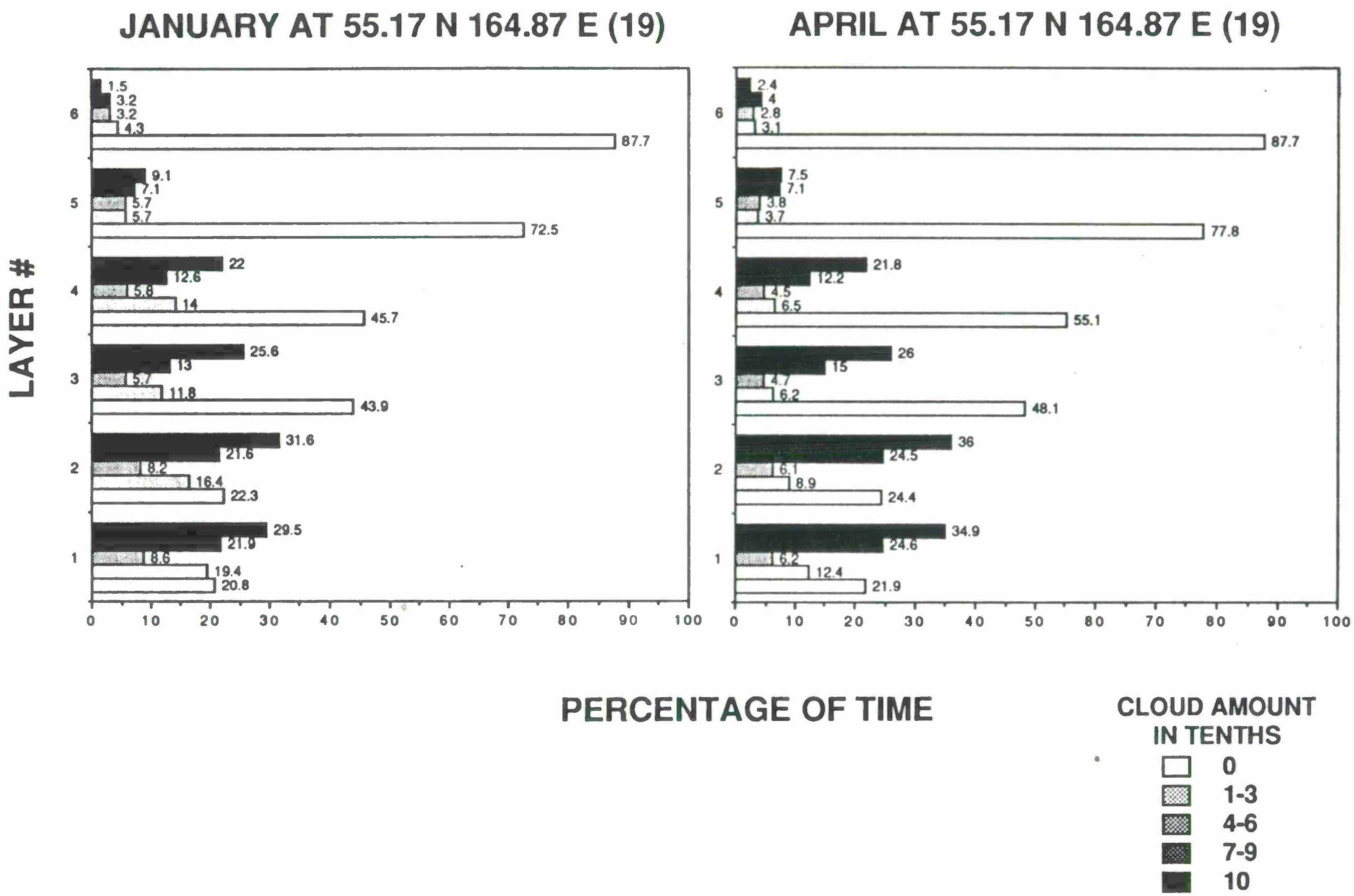

JULY AT 55.05 N 175.26 E (17)
OCTOBER AT 55.05 N 175.26 E (17)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT
IN TENTHS
0
1-3
4-6
7-9
10

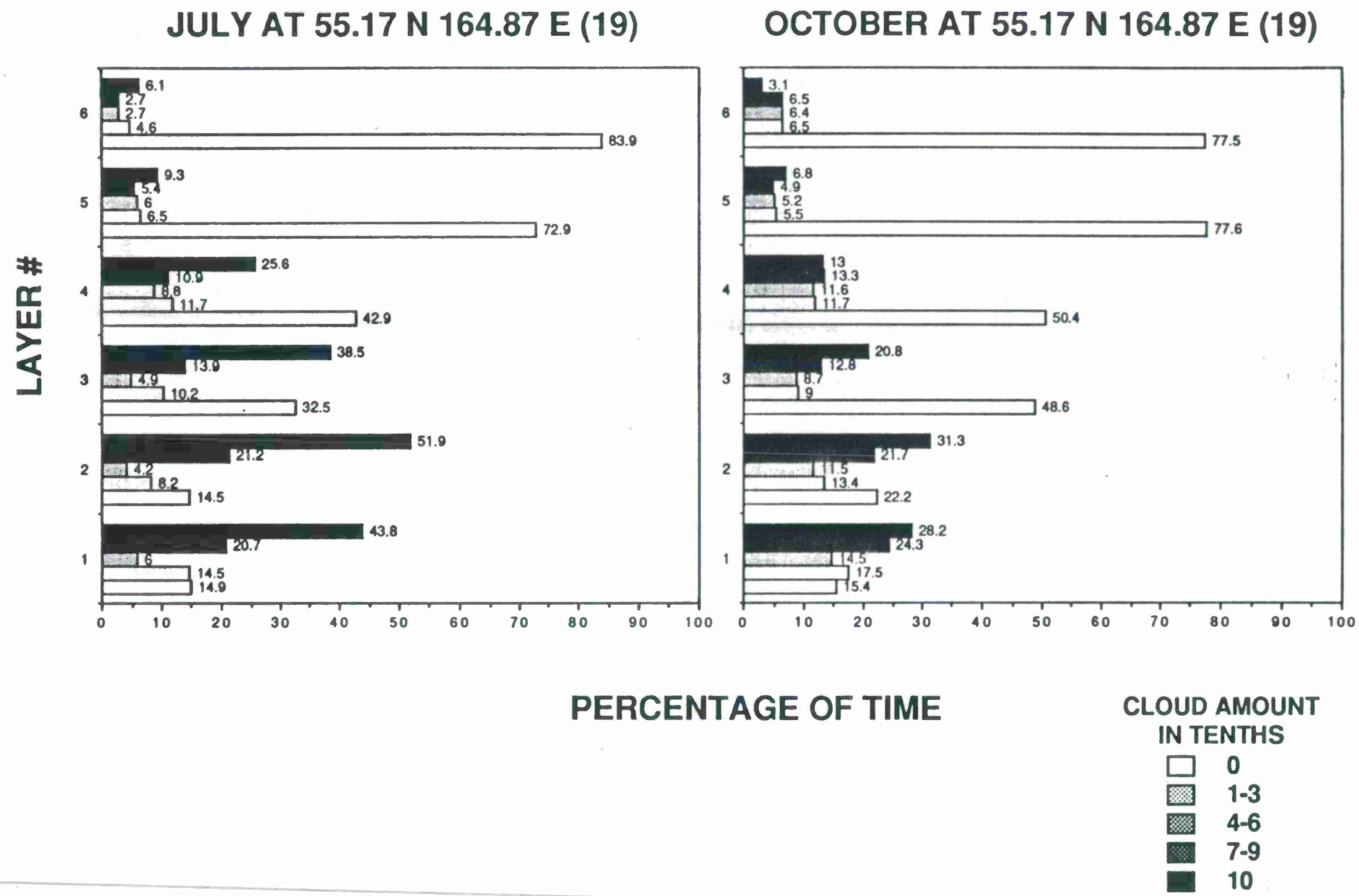


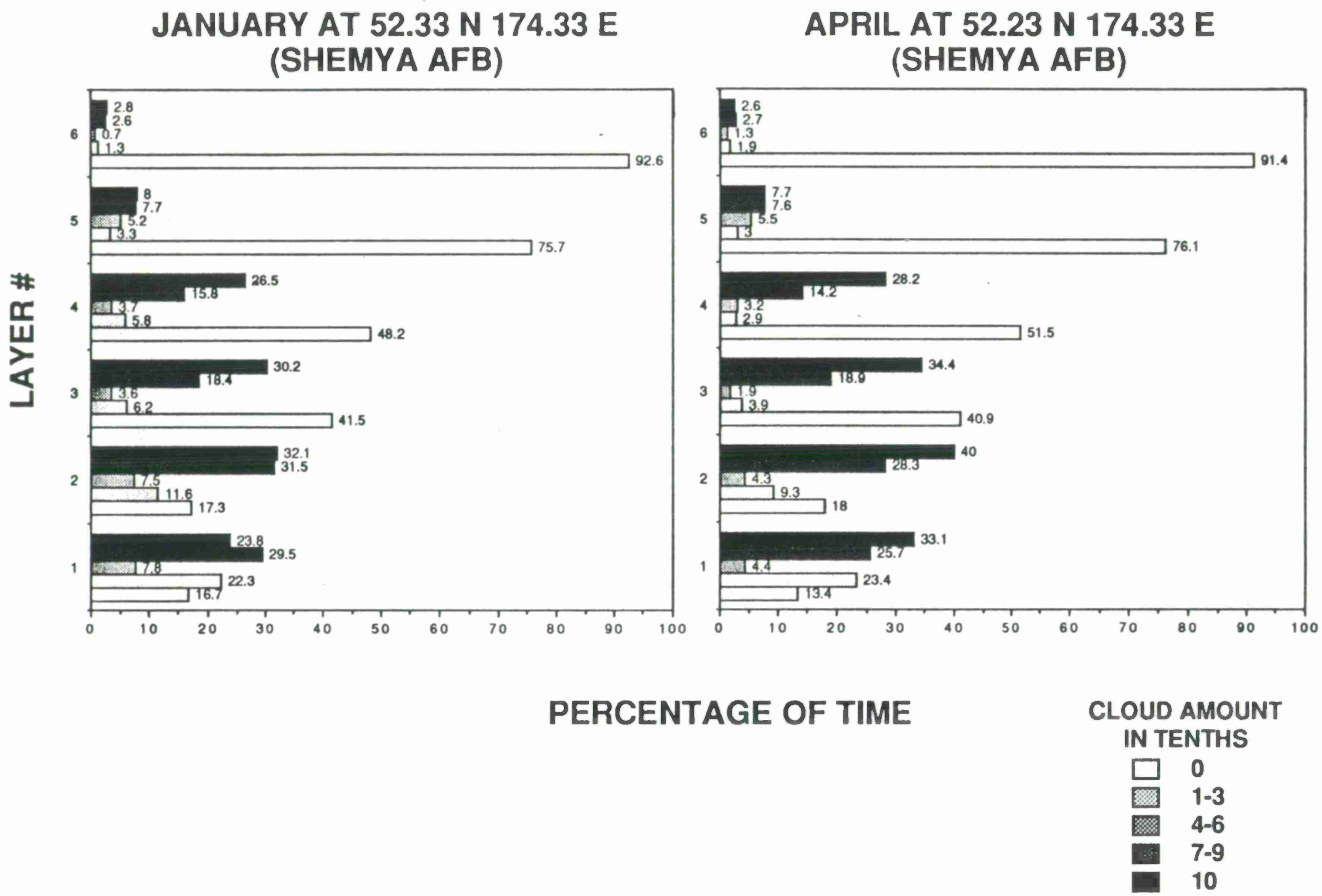
JANUARY AT 55.17 N 175.13 E (18)
APRIL AT 55.17 N 175.13 E (18)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

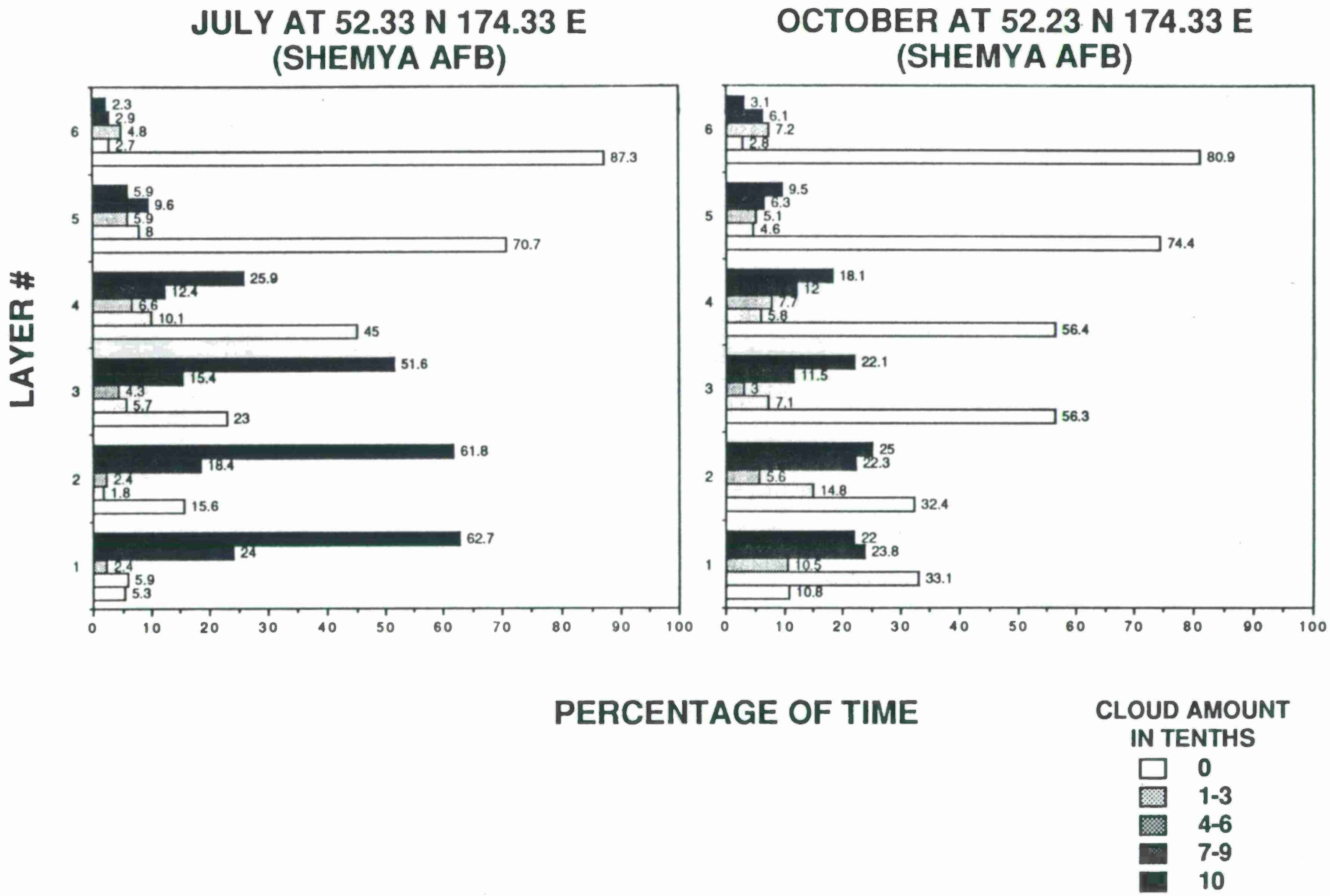
JULY AT 55.17 N 175.13 E (18) OCTOBER AT 55.17 N 175.13 E (18)

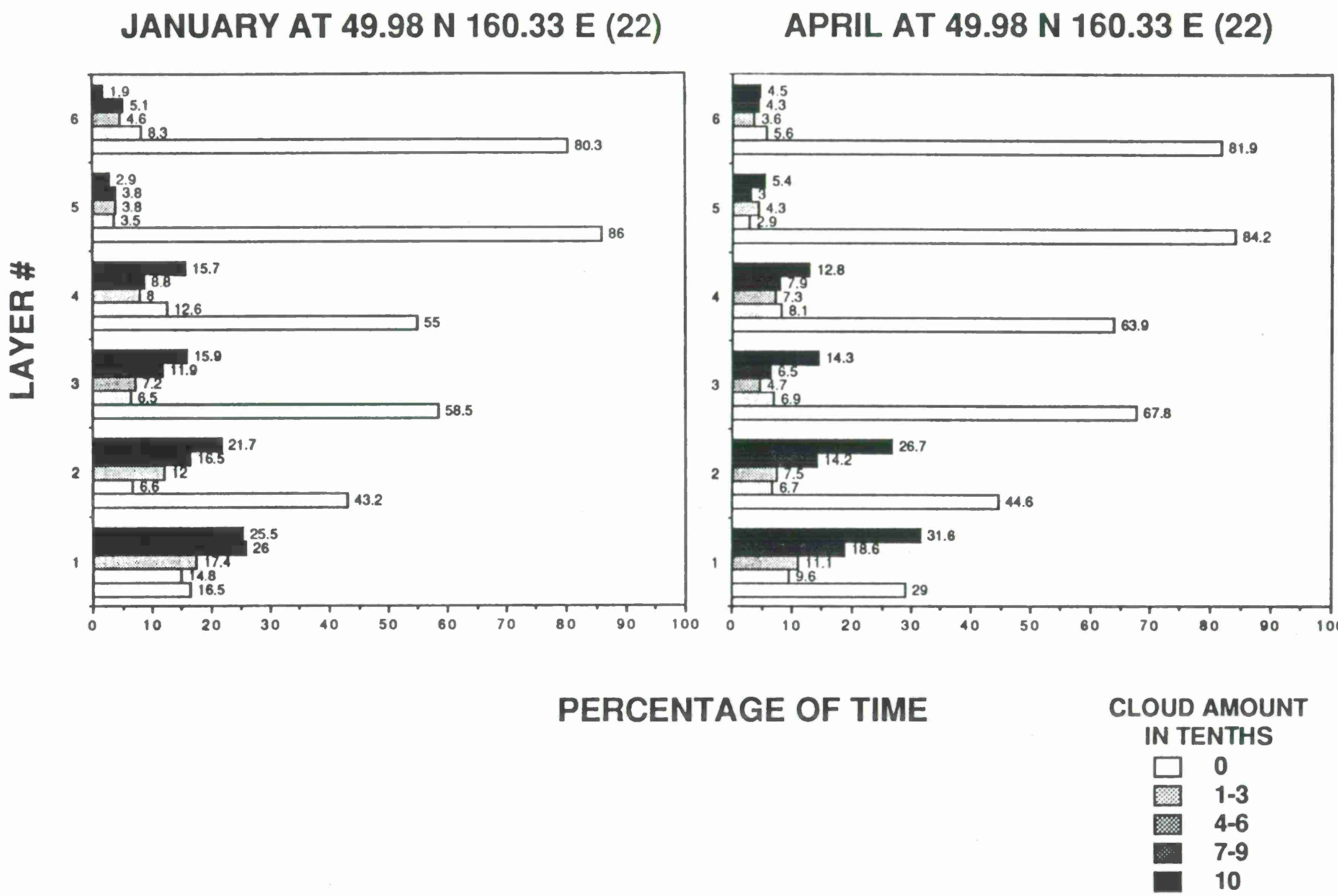



JANUARY AT 55.17 N 164.87 E (19)
APRIL AT 55.17 N 164.87 E (19)
LAYER #
PERCENTAGE OF TIME
0 10 20 30 40 50 60 70 80 90 100
6
1.5
3.2
3.2
4.3
87.7
5
9.1
7.1
5.7
5.7
72.5
4
22
12.6
5.8
14
45.7
3
25.6
13
5.7
11.8
43.9
2
31.6
21.6
8.2
16.4
22.3
1
29.5
21.9
8.6
19.4
20.8
2.4
4
2.8
3.1
87.7
7.5
7.1
3.8
3.7
77.8
21.8
12.2
4.5
6.5
55.1
26
15
4.7
6.2
48.1
36
24.5
6.1
8.9
24.4
34.9
24.6
6.2
12.4
21.9
CLOUD AMOUNT
IN TENTHS
0
1-3
4-6
7-9
10

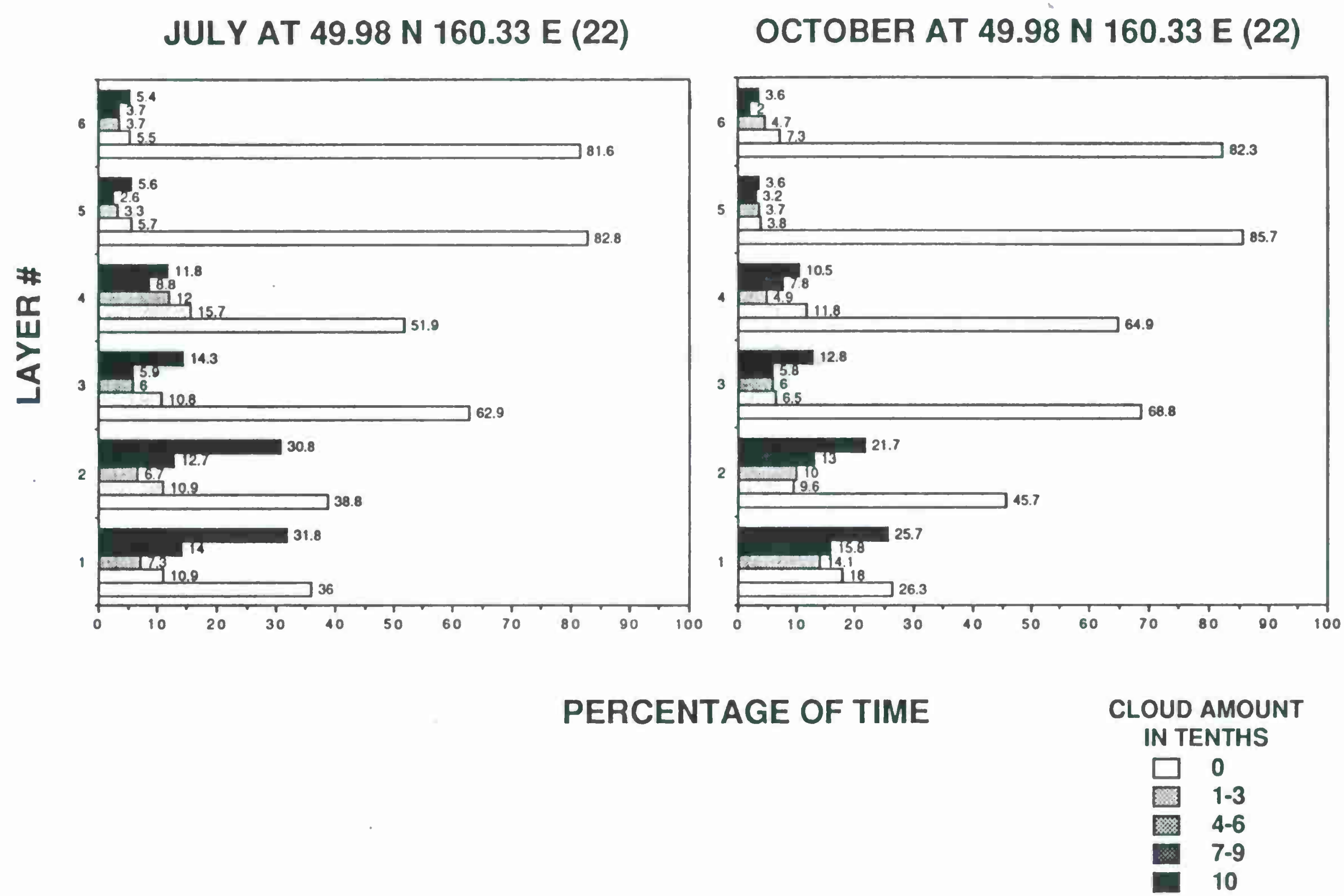

JULY AT 55.17 N 164.87 E (19)
OCTOBER AT 55.17 N 164.87 E (19)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10


JANUARY AT 52.33 N 174.33 E
(SHEMYA AFB)
APRIL AT 52.23 N 174.33 E
(SHEMYA AFB)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT
IN TENTHS
0
1-3
4-6
7-9
10

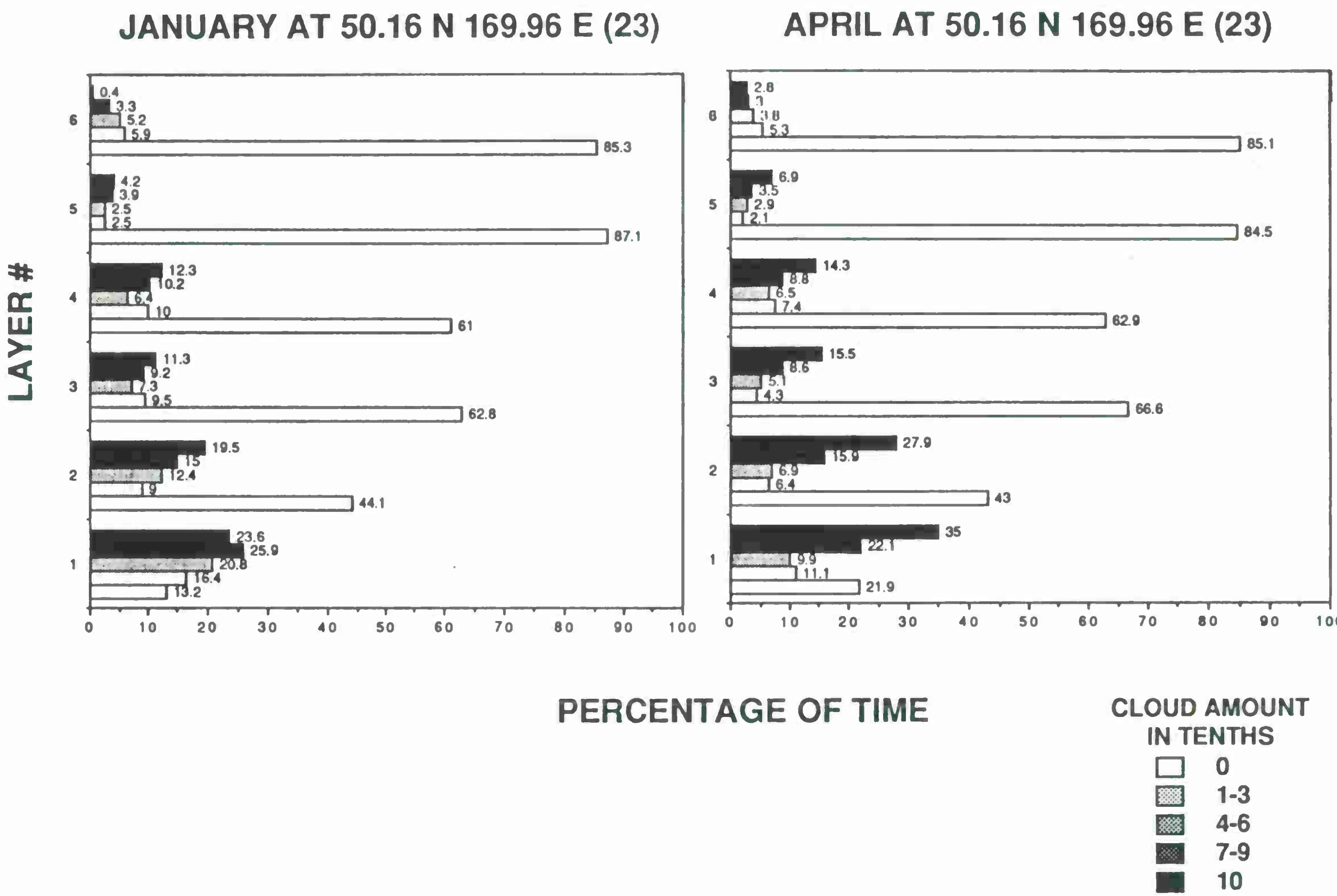

JULY AT 52.33 N 174.33 E
(SHEMYA AFB)
OCTOBER AT 52.23 N 174.33 E
(SHEMYA AFB)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT
IN TENTHS
0
1-3
4-6
7-9
10



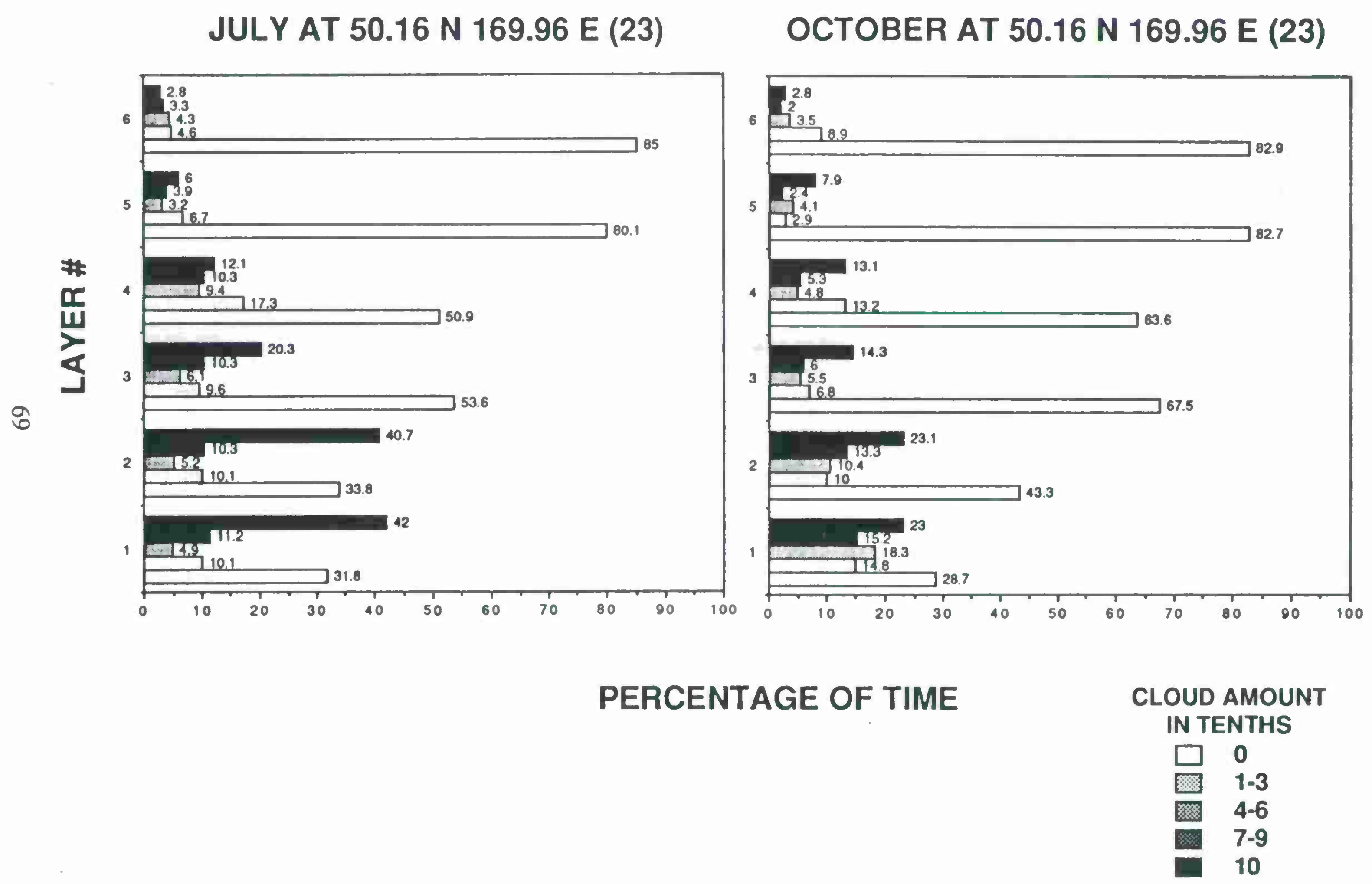
JANUARY AT 49.98 N 160.33 E (22)
APRIL AT 49.98 N 160.33 E (22)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10



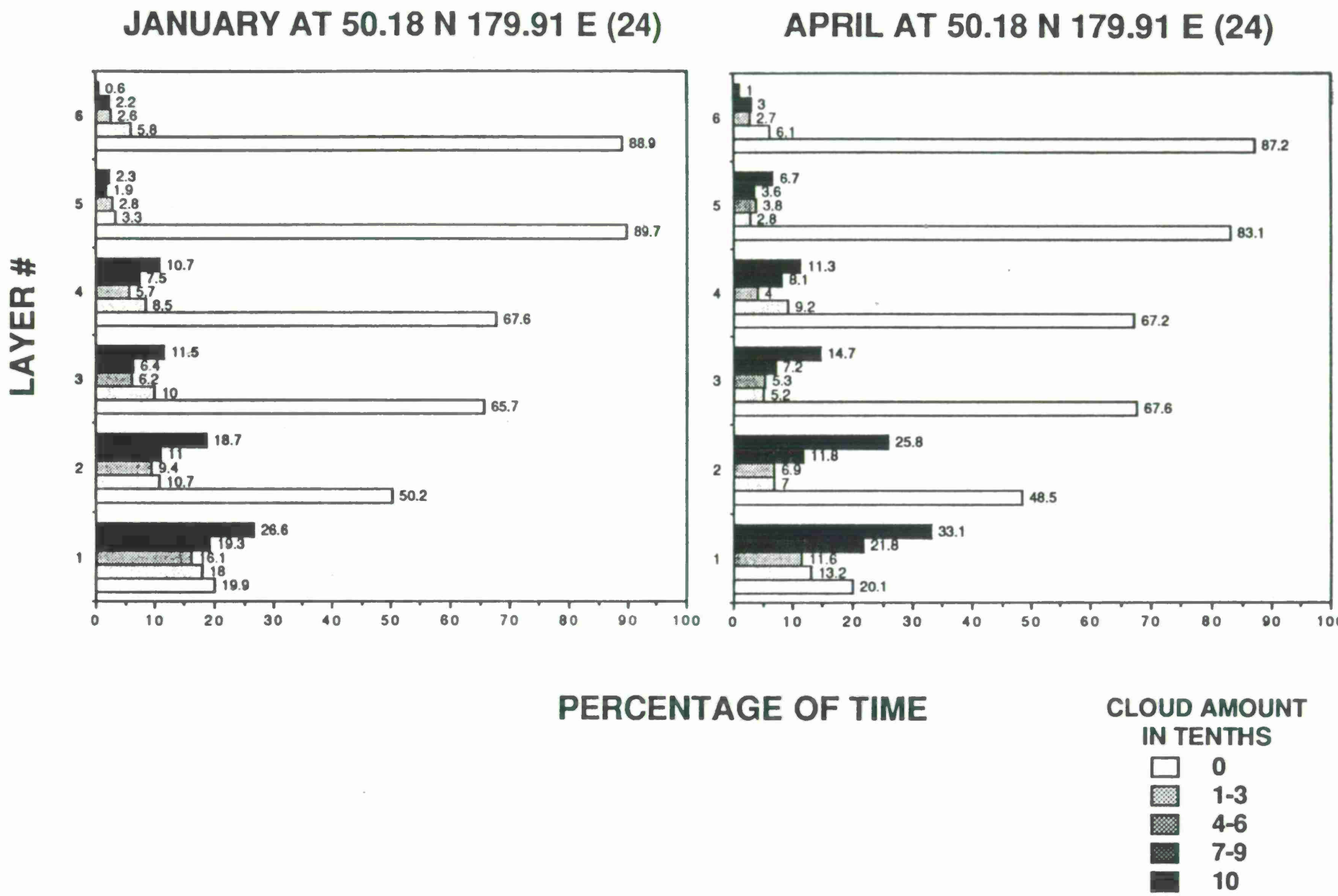
JULY AT 49.98 N 160.33 E (22)
OCTOBER AT 49.98 N 160.33 E (22)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10



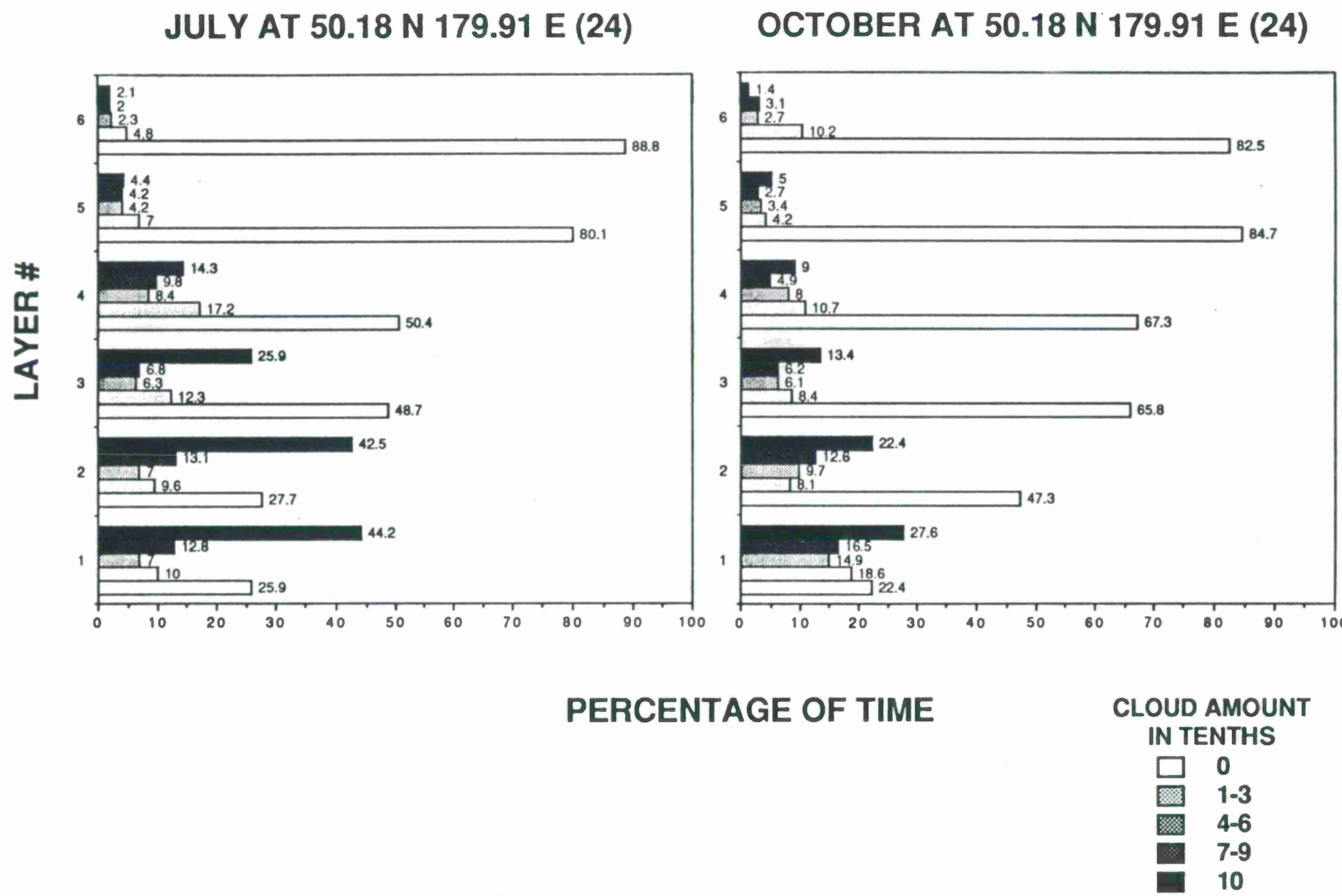
JANUARY AT 50.16 N 169.96 E (23)
APRIL AT 50.16 N 169.96 E (23)
LAYER #
6
0.4
3.3
5.2
5.9
85.3
5
4.2
3.9
2.5
2.5
87.1
4
12.3
10.2
6.4
10
61
3
11.3
9.2
7.3
9.5
62.8
2
19.5
15
12.4
9
44.1
1
23.6
25.9
20.8
16.4
13.2
2.8
3
3.8
5.3
85.1
6.9
3.5
2.9
2.1
84.5
14.3
8.8
6.5
7.4
62.9
15.5
8.6
5.1
4.3
66.6
27.9
15.9
6.9
6.4
43
35
22.1
9.9
11.1
21.9
0 10 20 30 40 50 60 70 80 90 100
0 10 20 30 40 50 60 70 80 90 100
PERCENTAGE OF TIME
CLOUD AMOUNT
IN TENTHS
0
1-3
4-6
7-9
10



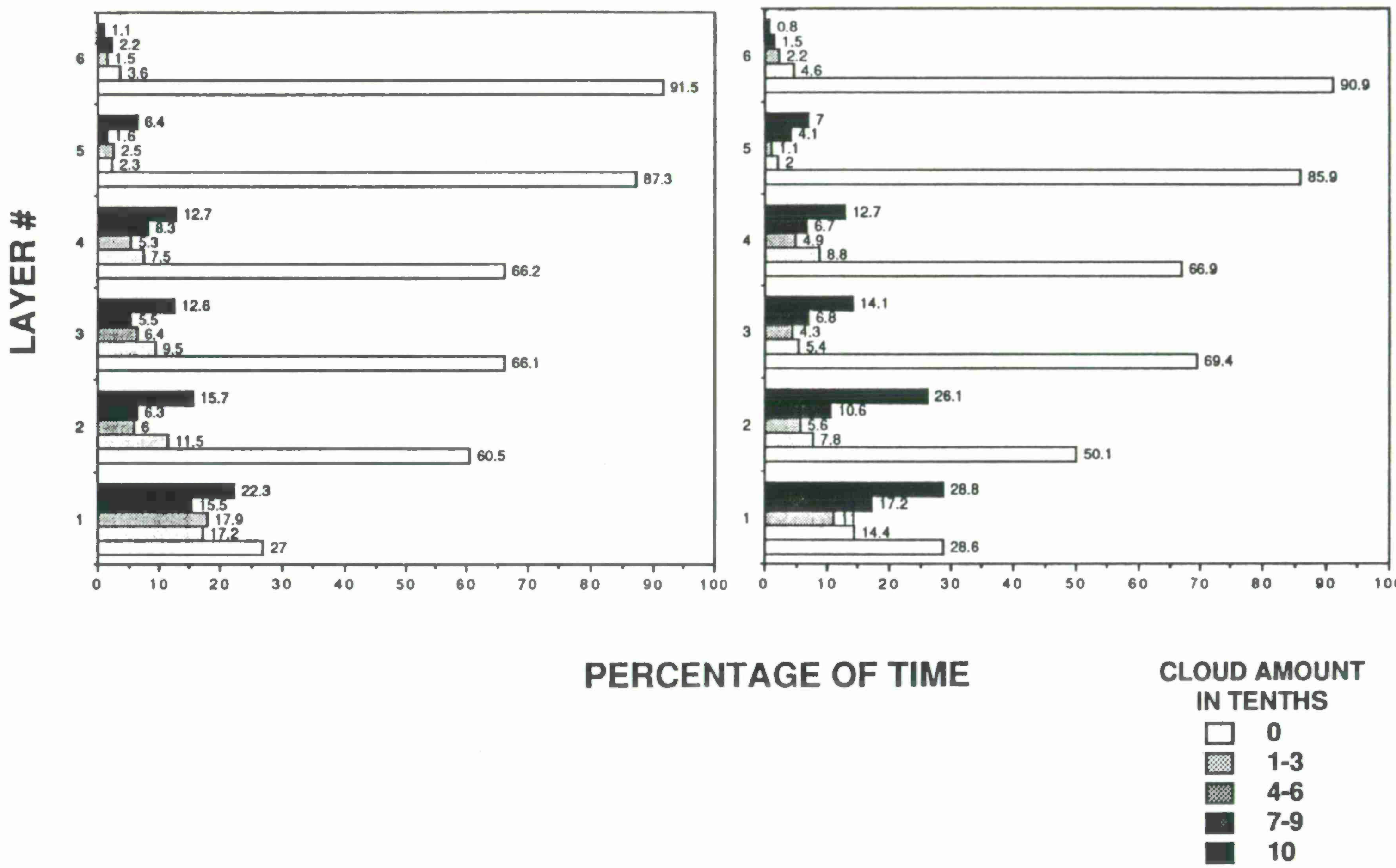
JULY AT 50.16 N 169.96 E (23)
OCTOBER AT 50.16 N 169.96 E (23)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

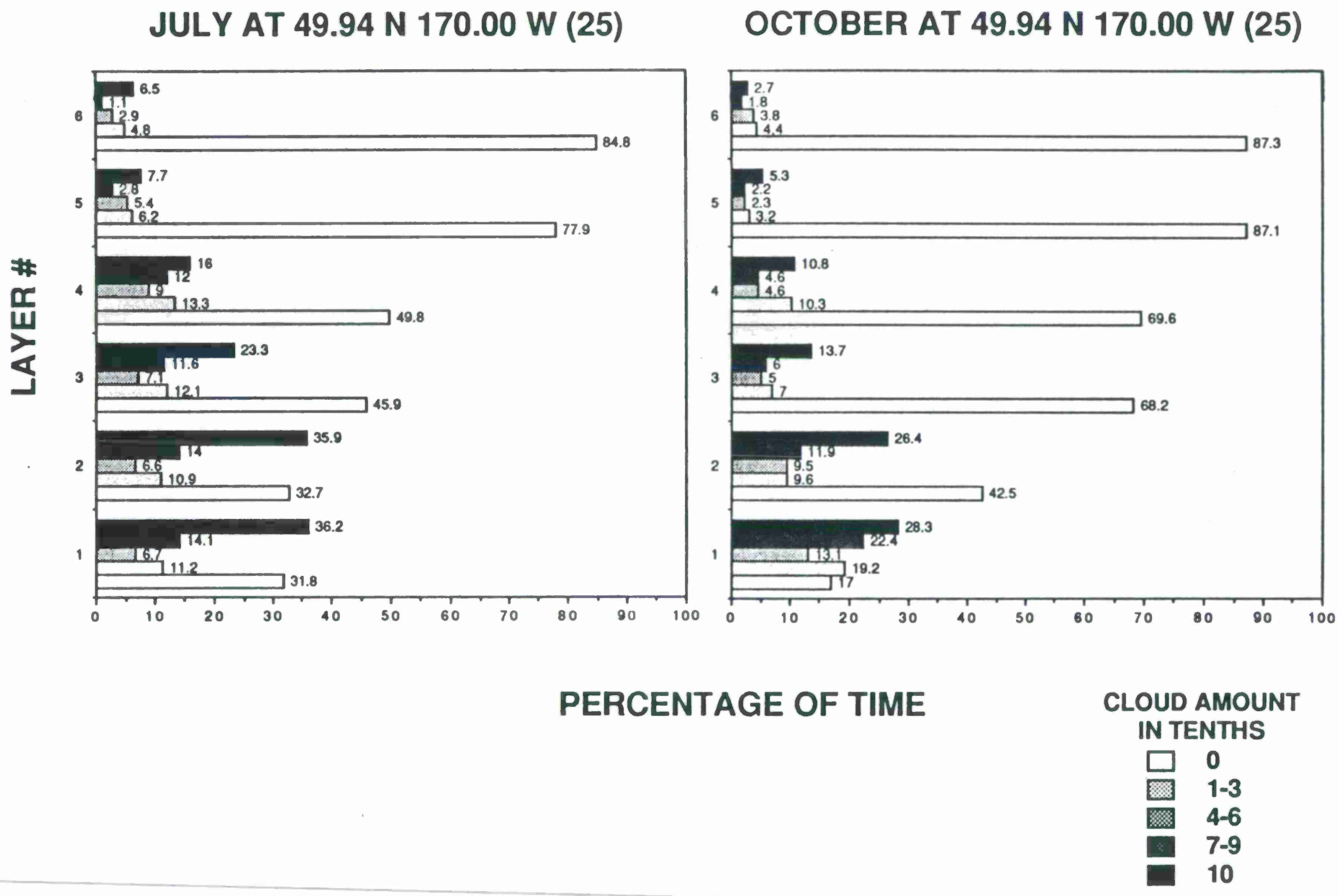


JANUARY AT 50.18 N 179.91 E (24)
APRIL AT 50.18 N 179.91 E (24)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10
0.6
2.2
2.6
5.8
88.9
2.3
1.9
2.8
3.3
89.7
10.7
7.5
5.7
8.5
67.6
11.5
6.4
6.2
10
65.7
18.7
11
9.4
10.7
50.2
26.6
19.3
6.1
18
19.9
1
3
2.7
6.1
87.2
6.7
3.6
3.8
2.8
83.1
11.3
8.1
4
9.2
67.2
14.7
7.2
5.3
5.2
67.6
25.8
11.8
6.9
7
48.5
33.1
21.8
11.6
13.2
20.1

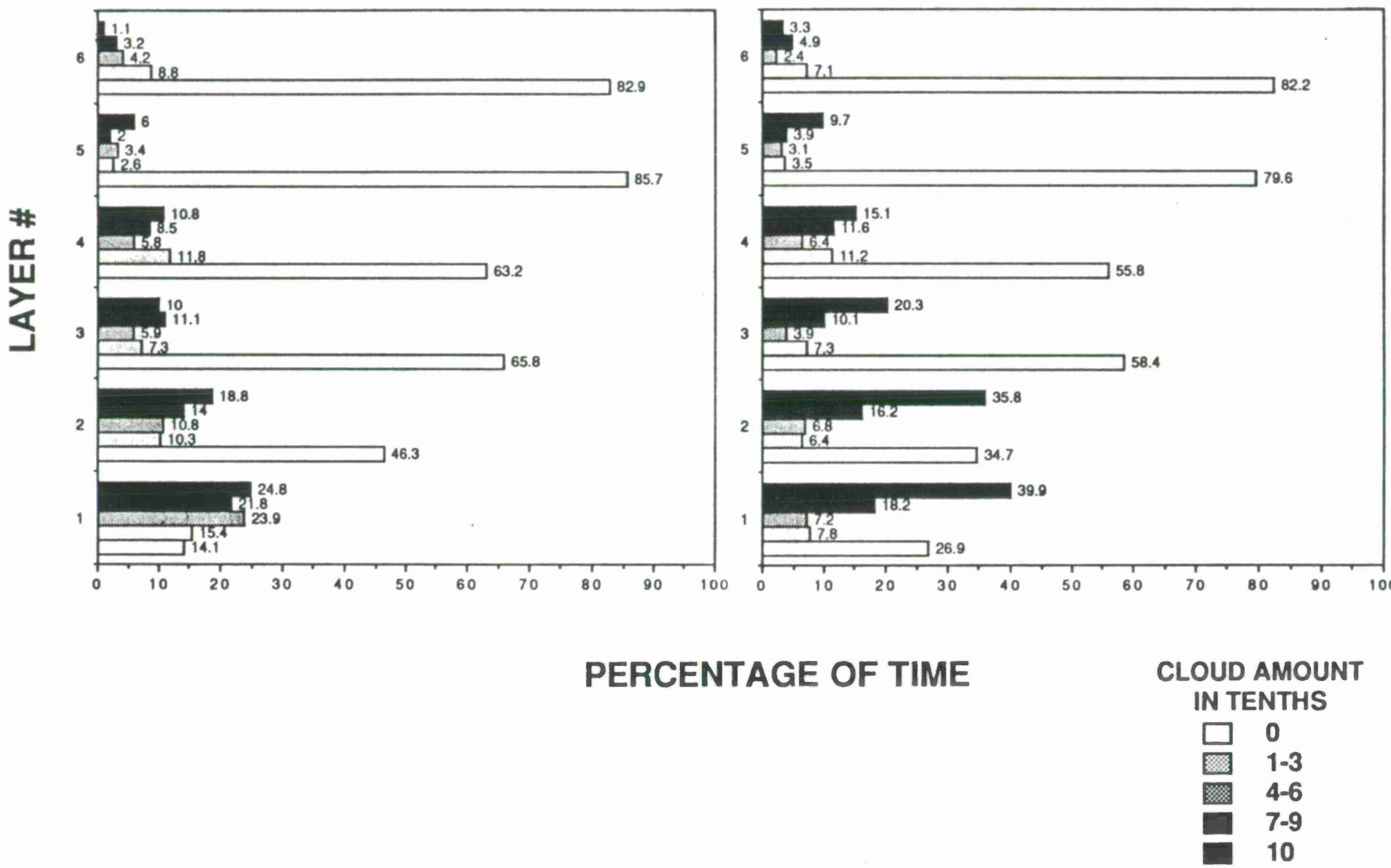

JULY AT 50.18 N 179.91 E (24)
OCTOBER AT 50.18 N 179.91 E (24)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

JANUARY AT 49.94 N 170.00 W (25)　　APRIL AT 49.94 N 170.00 W (25)



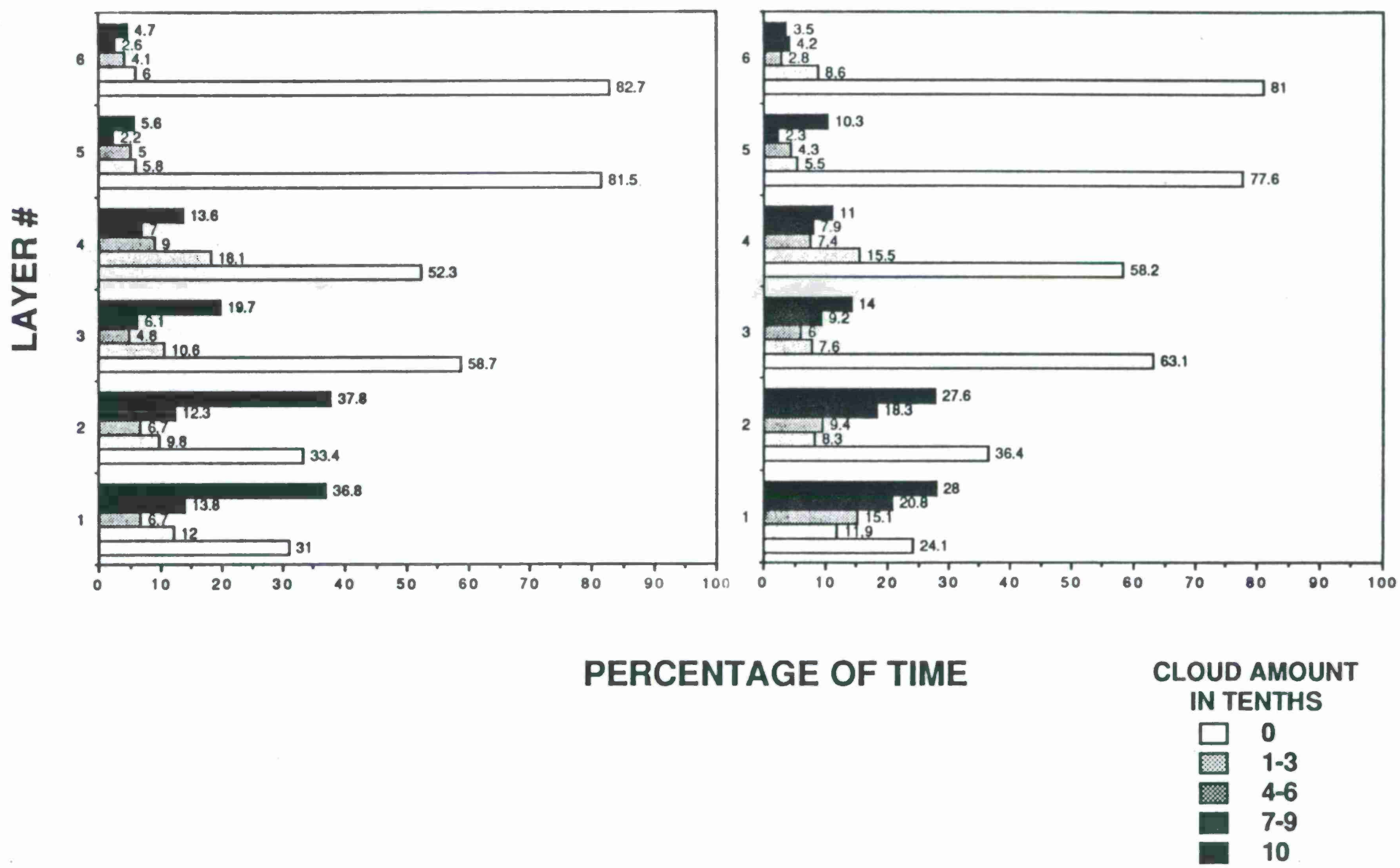

JULY AT 49.94 N 170.00 W (25)
OCTOBER AT 49.94 N 170.00 W (25)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

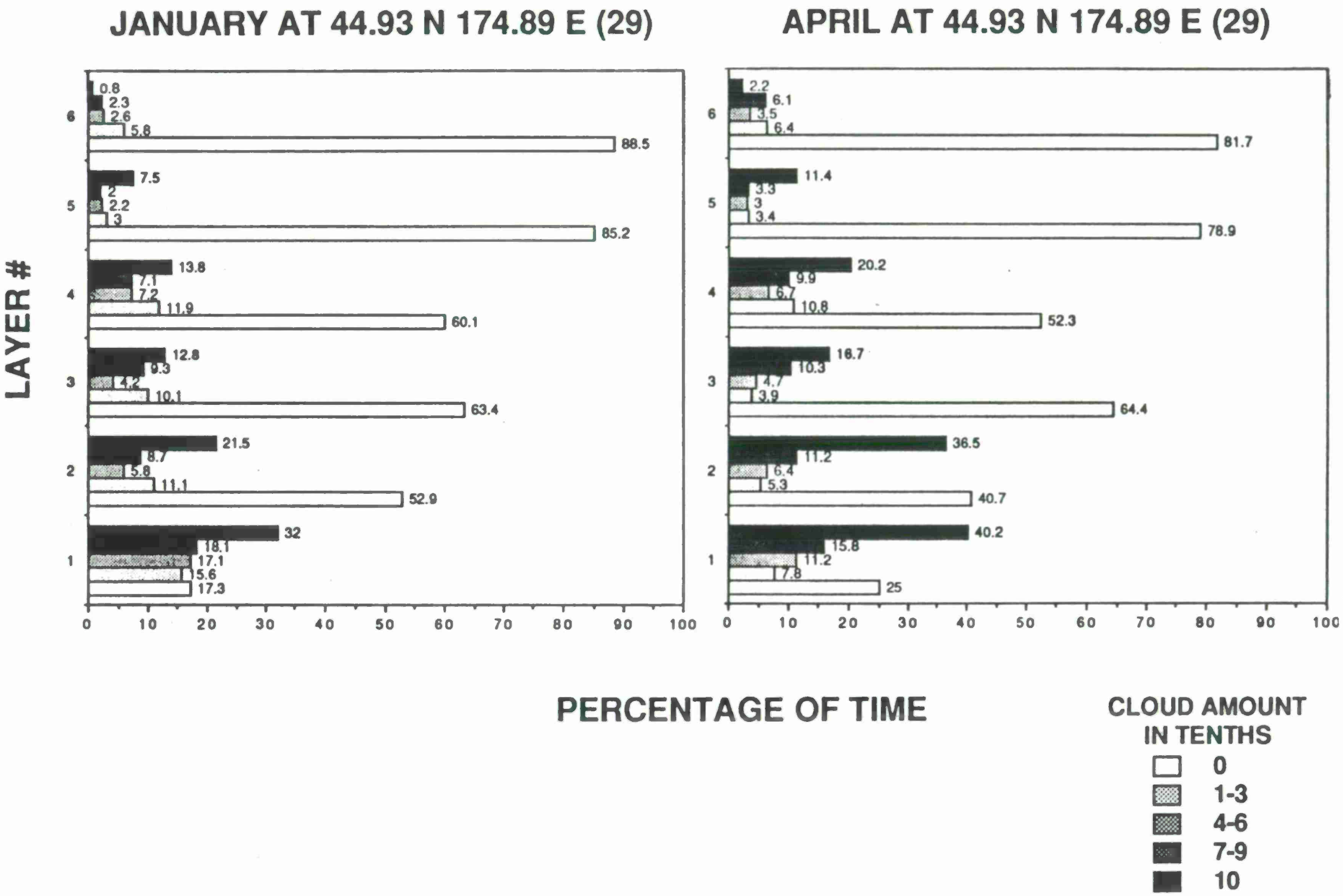
JANUARY AT 44.85 N 164.92 E (28) — APRIL AT 44.85 N 164.92 E (28)

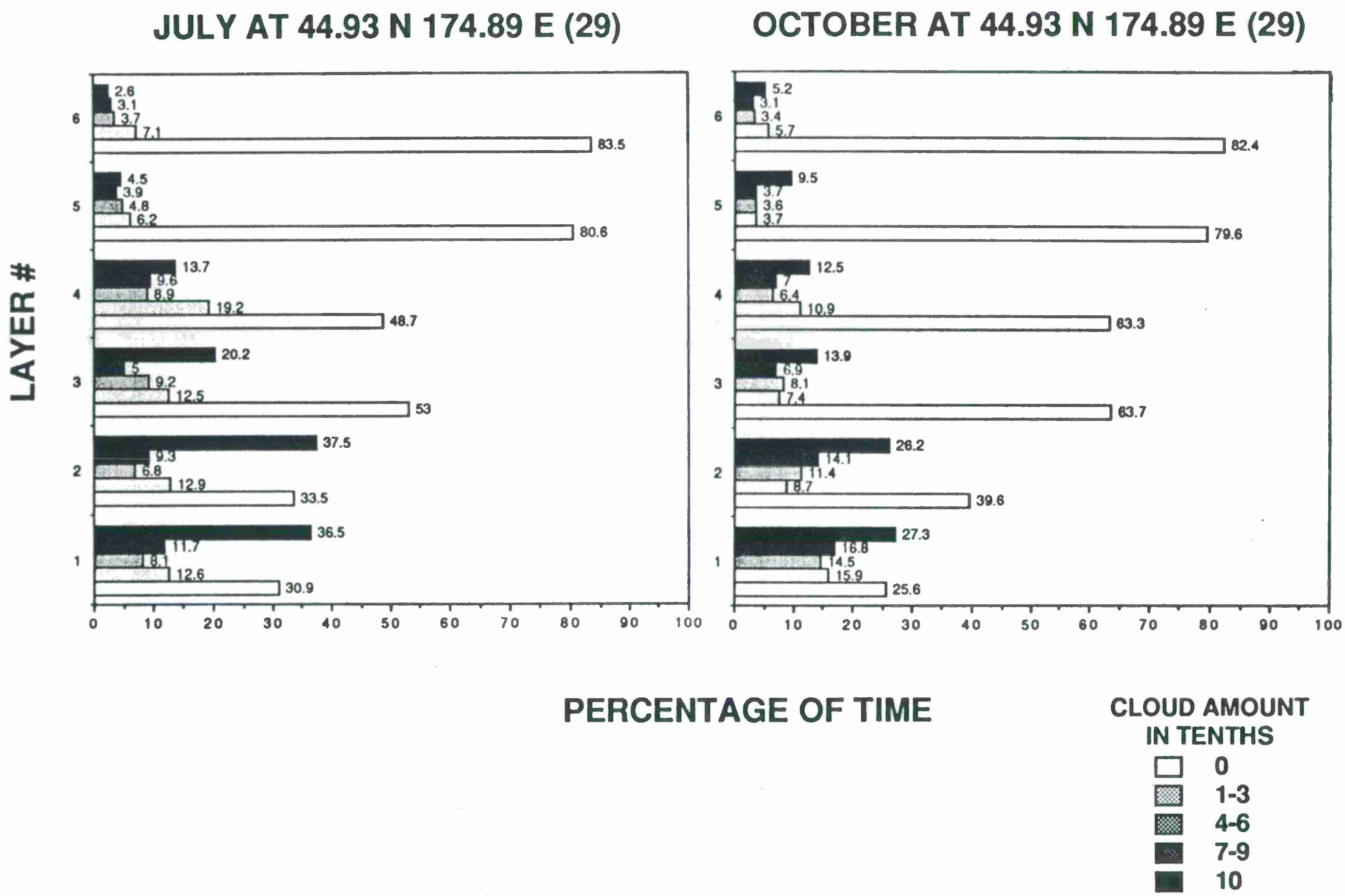


JULY AT 44.85 N 164.92 E (28)

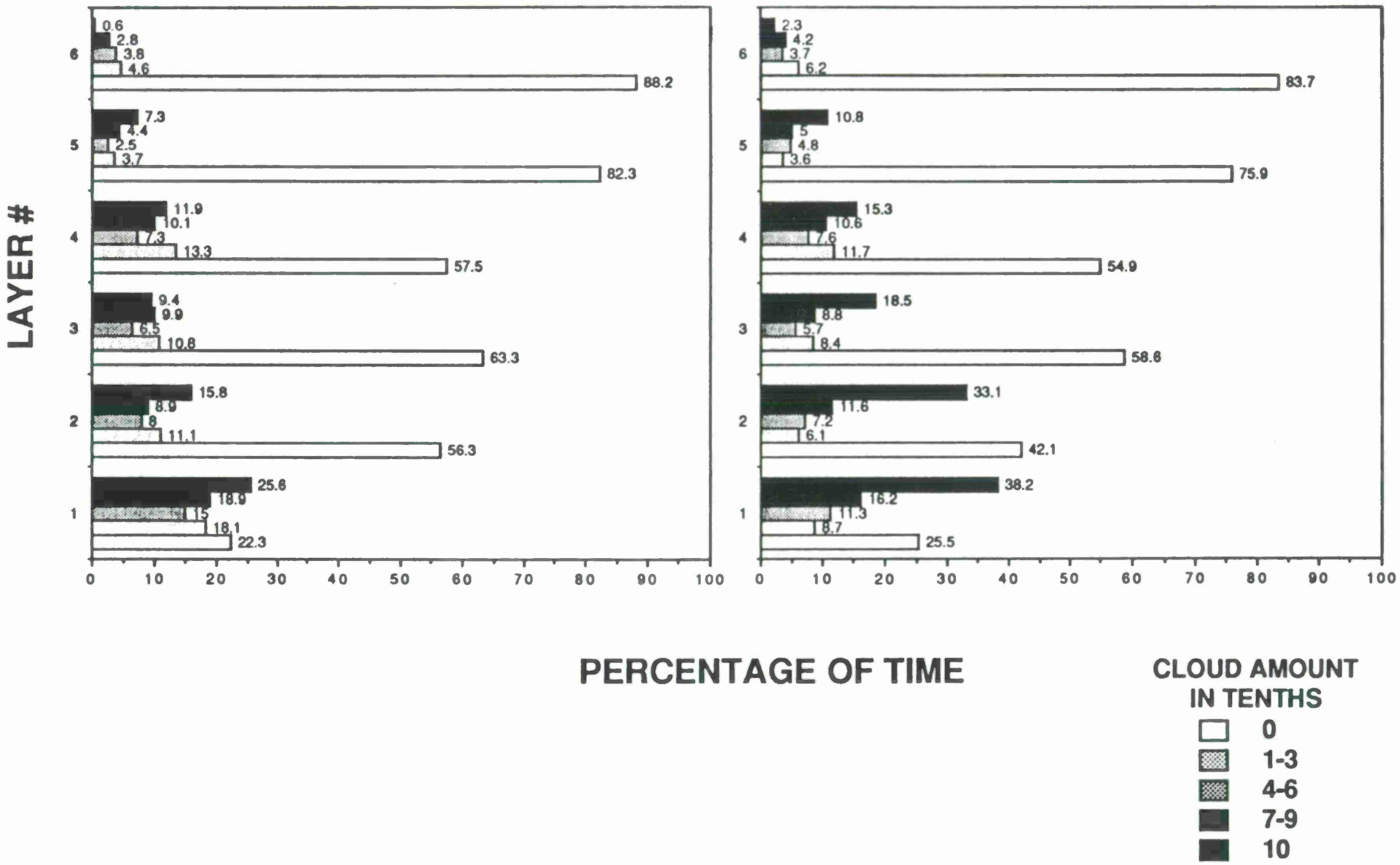
OCTOBER AT 44.85 N 164.92 E (28)




JANUARY AT 44.93 N 174.89 E (29)
APRIL AT 44.93 N 174.89 E (29)
LAYER #
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

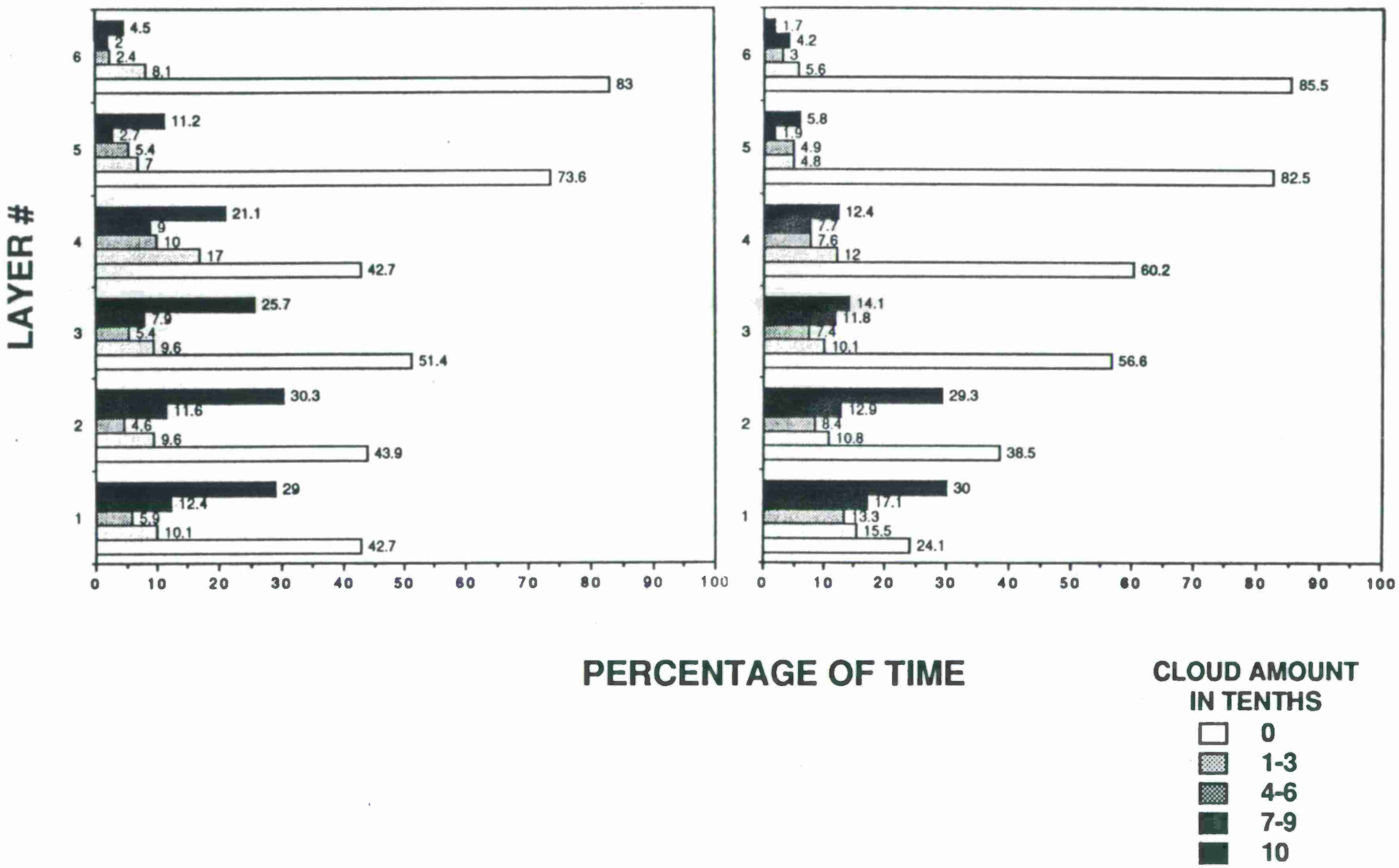

JULY AT 44.93 N 174.89 E (29)
OCTOBER AT 44.93 N 174.89 E (29)
LAYER #
6
5
4
3
2
1
2.6
3.1
3.7
7.1
83.5
4.5
3.9
4.8
6.2
80.6
13.7
9.6
8.9
19.2
48.7
20.2
5
9.2
12.5
53
37.5
9.3
6.8
12.9
33.5
36.5
11.7
8.1
12.6
30.9
5.2
3.1
3.4
5.7
82.4
9.5
3.7
3.6
3.7
79.6
12.5
7
6.4
10.9
63.3
13.9
6.9
8.1
7.4
63.7
26.2
14.1
11.4
8.7
39.6
27.3
16.8
14.5
15.9
25.6
0 10 20 30 40 50 60 70 80 90 100
PERCENTAGE OF TIME
CLOUD AMOUNT IN TENTHS
0
1-3
4-6
7-9
10

JANUARY AT 45.00 N 174.99 W (30)　　APRIL AT 45.00 N 174.99 W (30)



JULY AT 45.00 N 174.99 W (30)

OCTOBER AT 45.00 N 174.99 W (30)

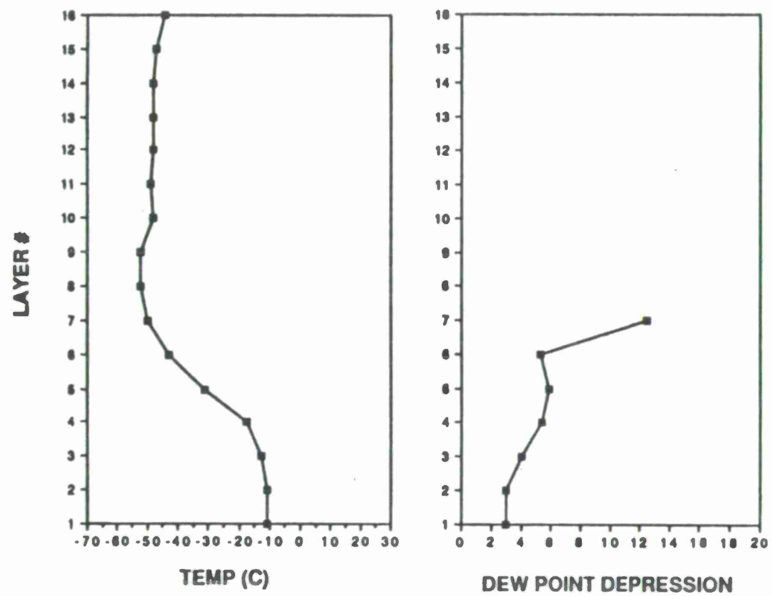


APPENDIX C

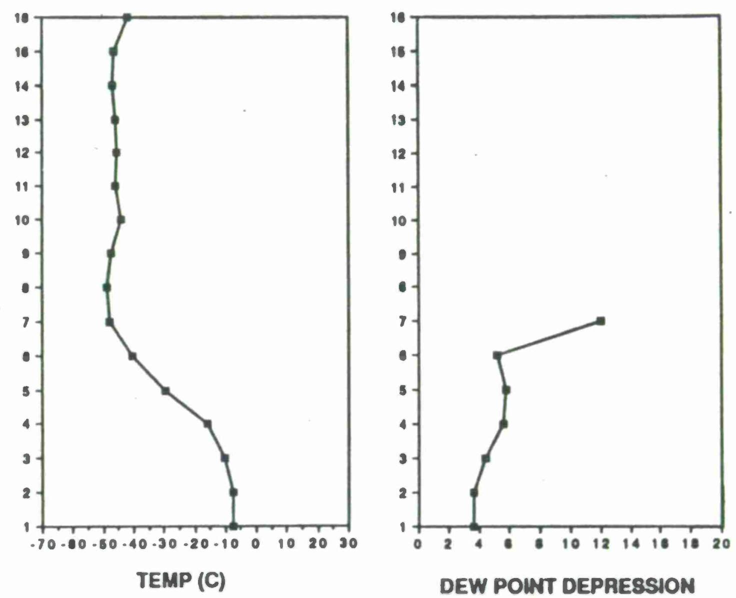
ATMOSPHERIC TEMPERATURE AND MOISTURE STATISTICS

(January, April, July, October)

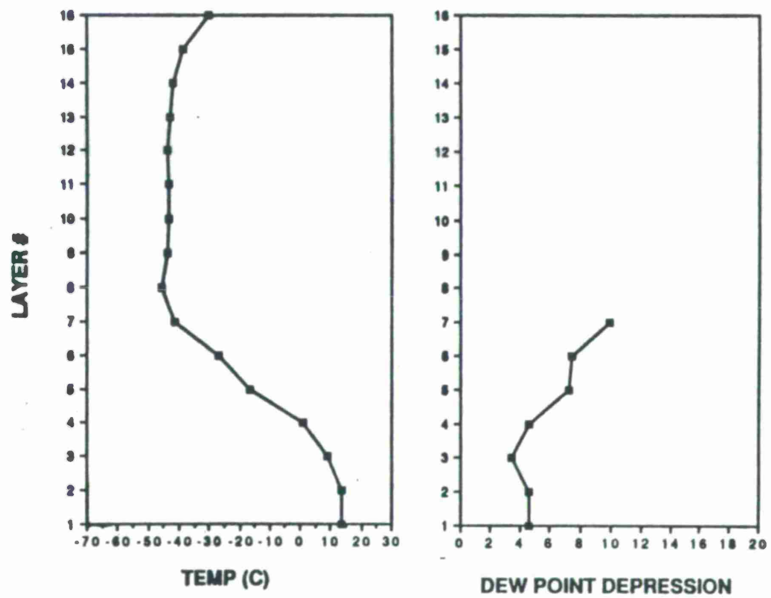
JANUARY AT 65.00 N 175.00 E (5)



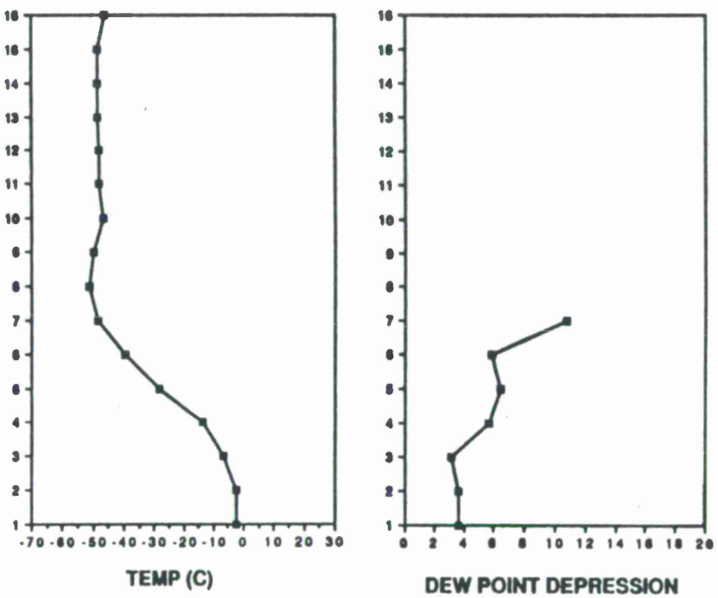
APRIL AT 65.00 N 175.00 E (5)



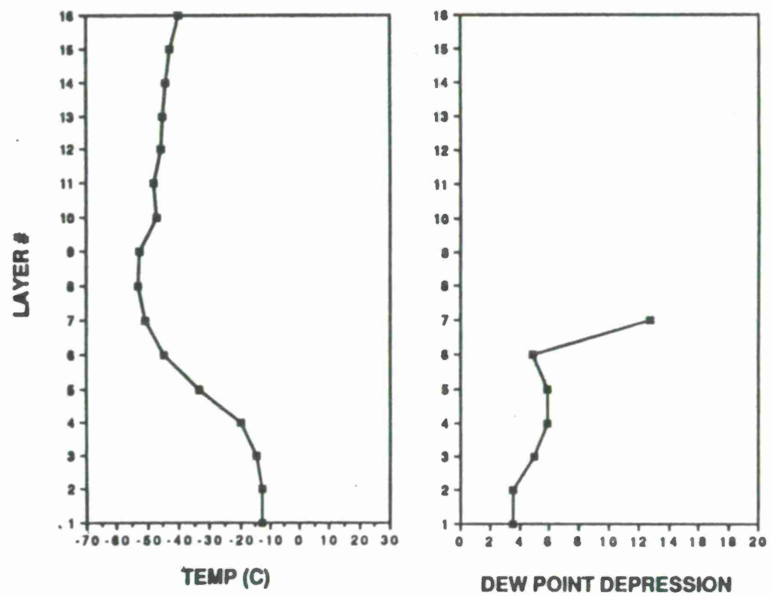
JULY AT 65.00 N 175.00 E (5)



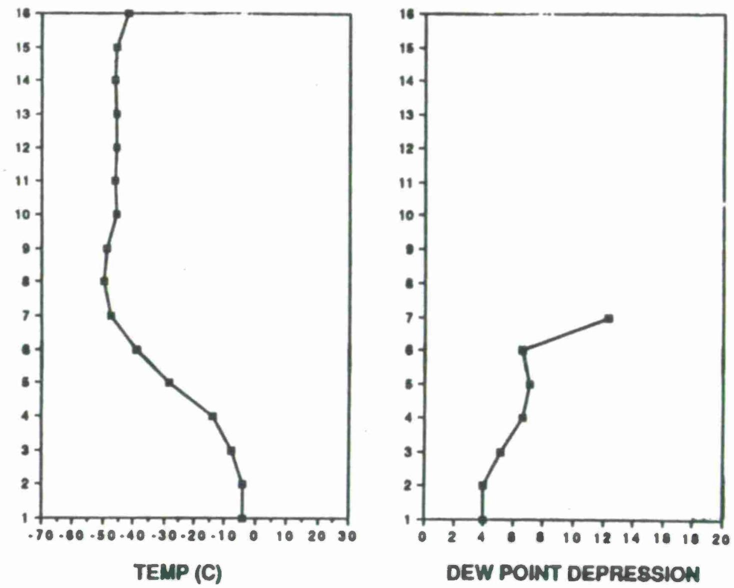
OCTOBER AT 65.00 N 175.00 E (5)



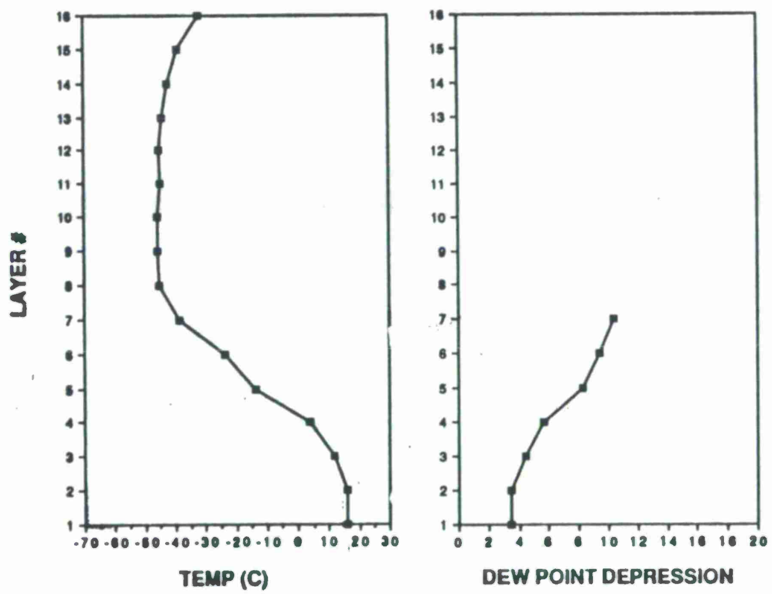
JANUARY AT 60.00 N 160.00 E (9)



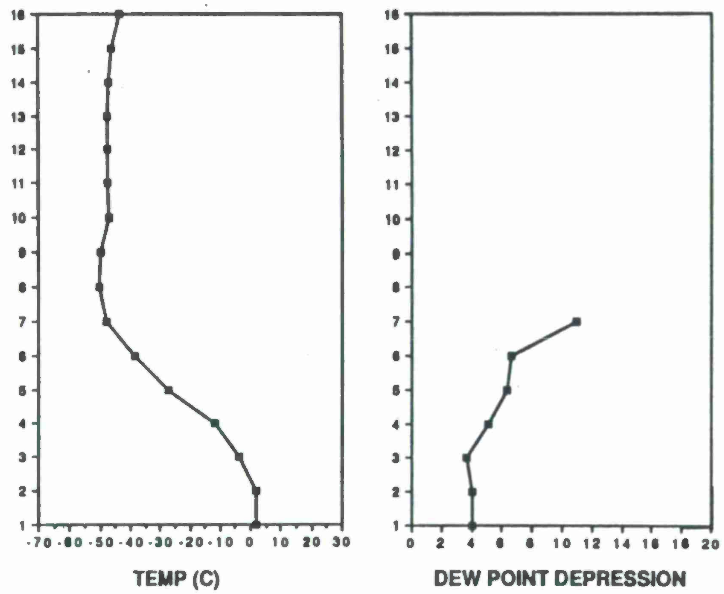
APRIL AT 60.00 N 160.00 E (9)



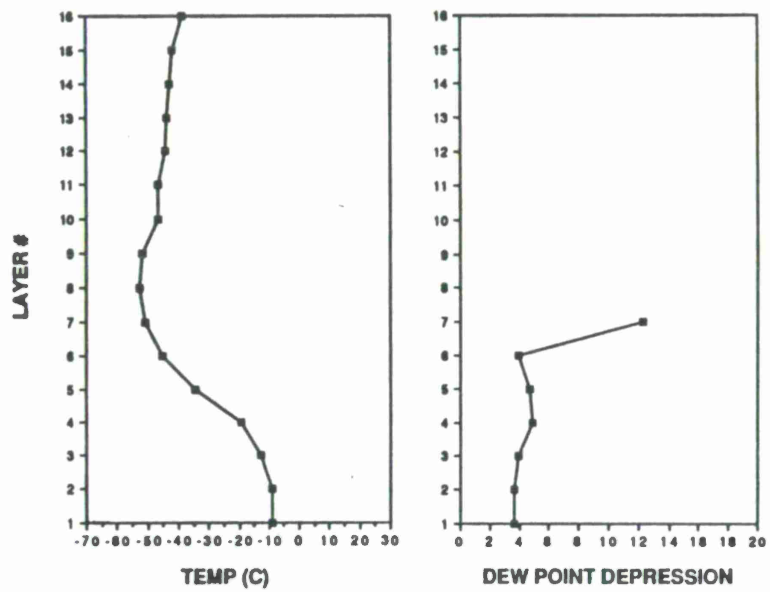
JULY AT 60.00 N 160.00 E (9)



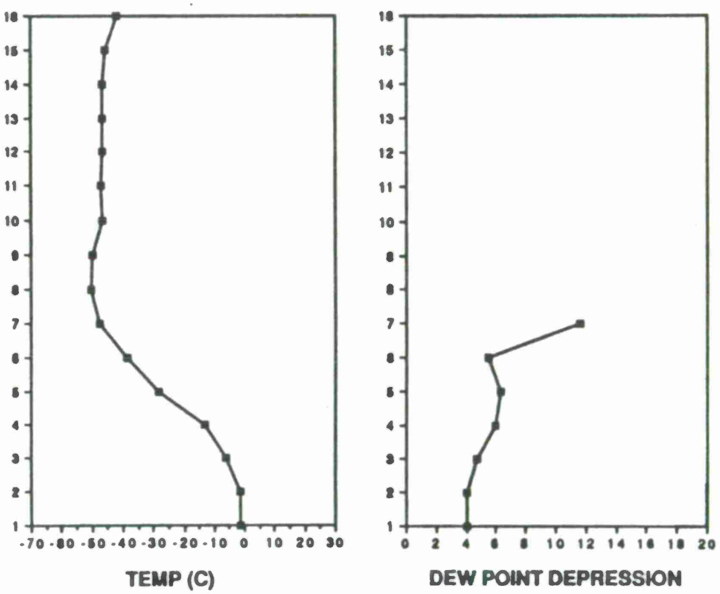
OCTOBER AT 60.00 N 160.00 E (9)



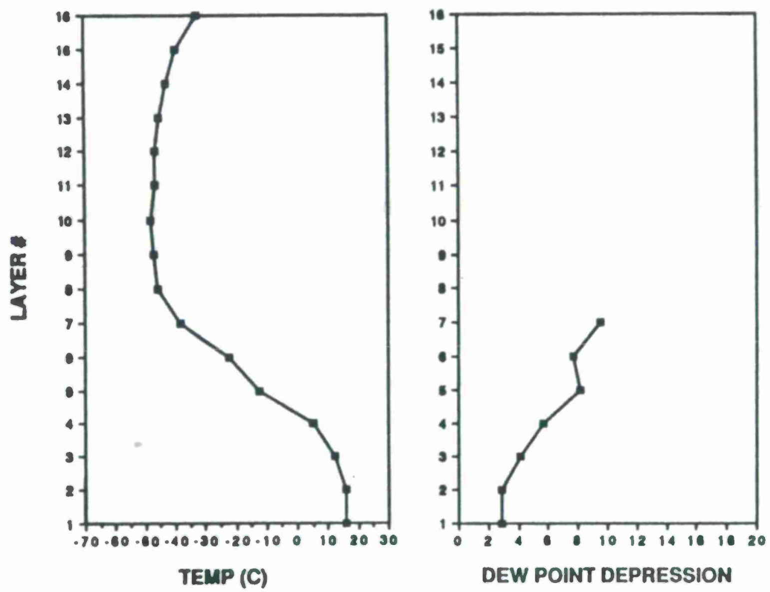
JANUARY AT 60.00 N 170.00 E (10)



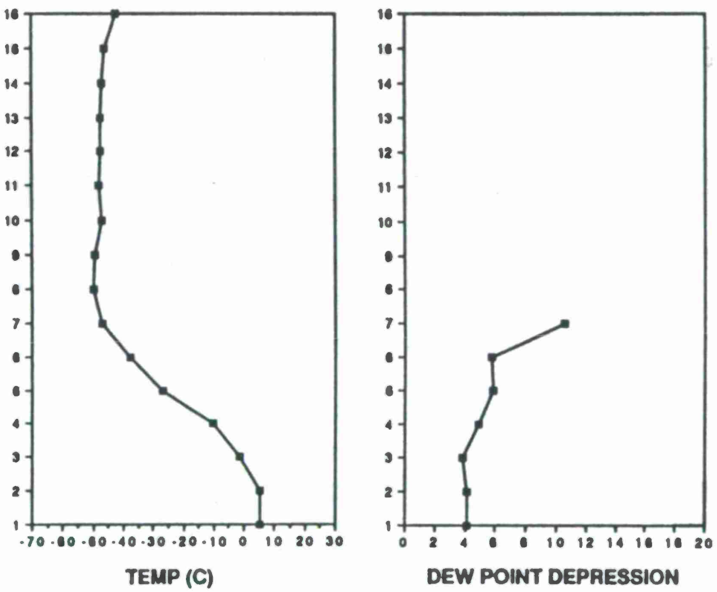
APRIL AT 60.00 N 170.00 E (10)



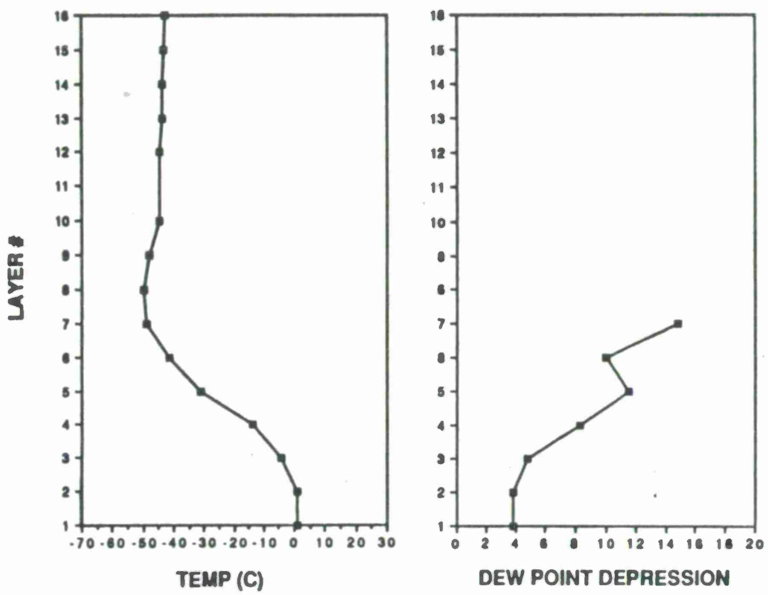
JULY AT 60.00 N 170.00 E (10)



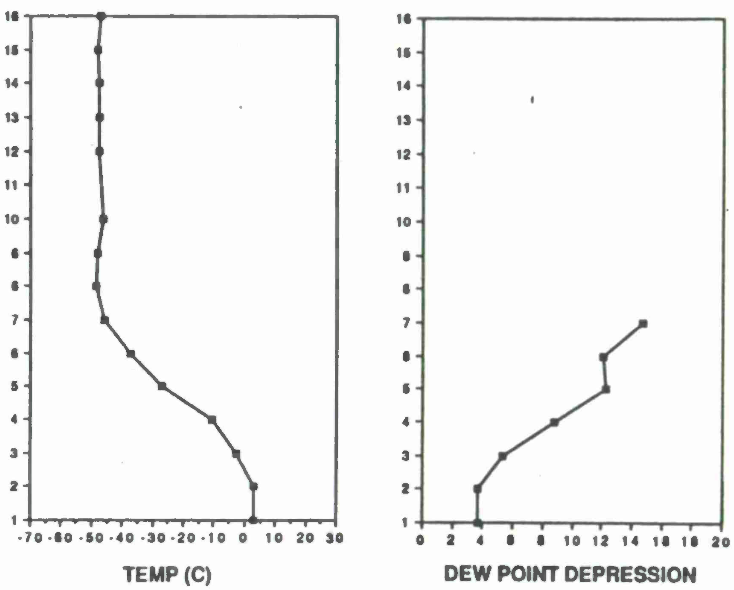
OCTOBER AT 60.00 N 170.00 E (10)

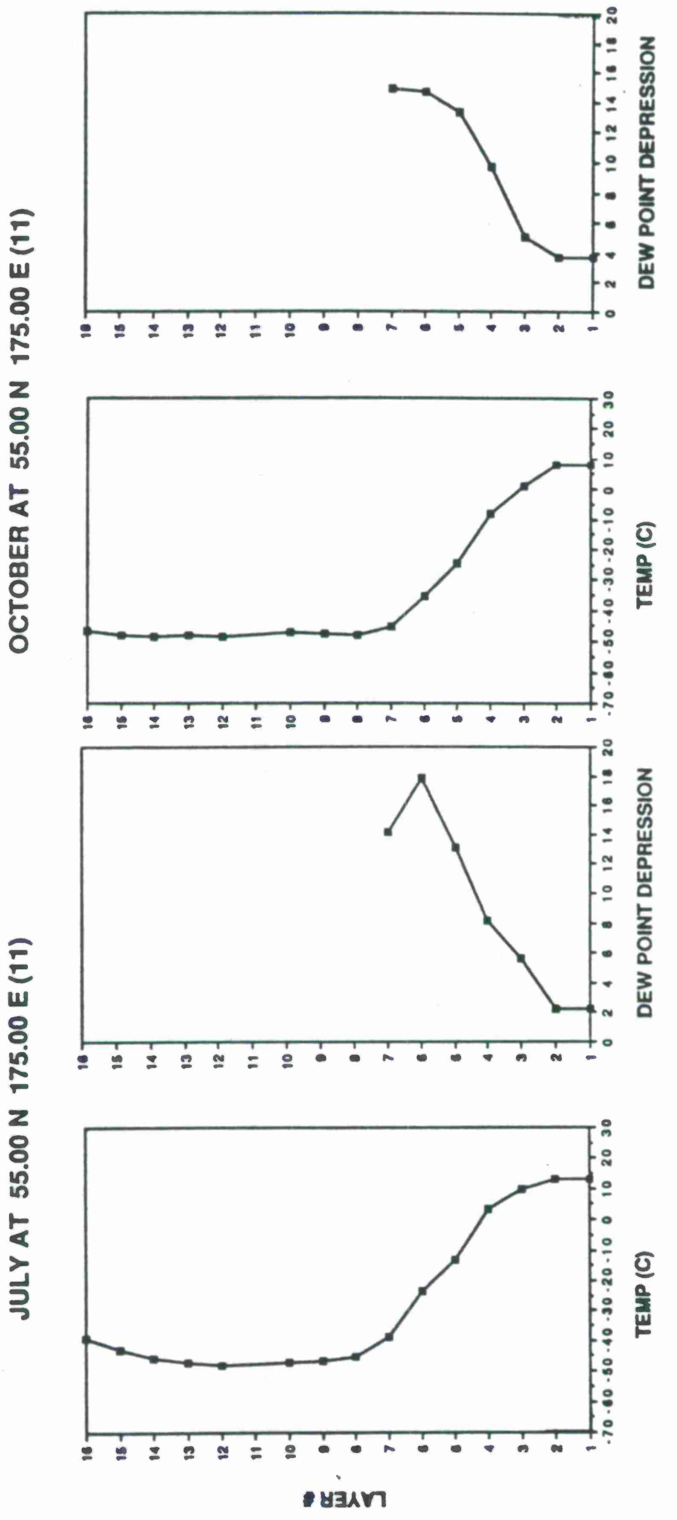


JANUARY AT 55.00 N 175.00 E (11)



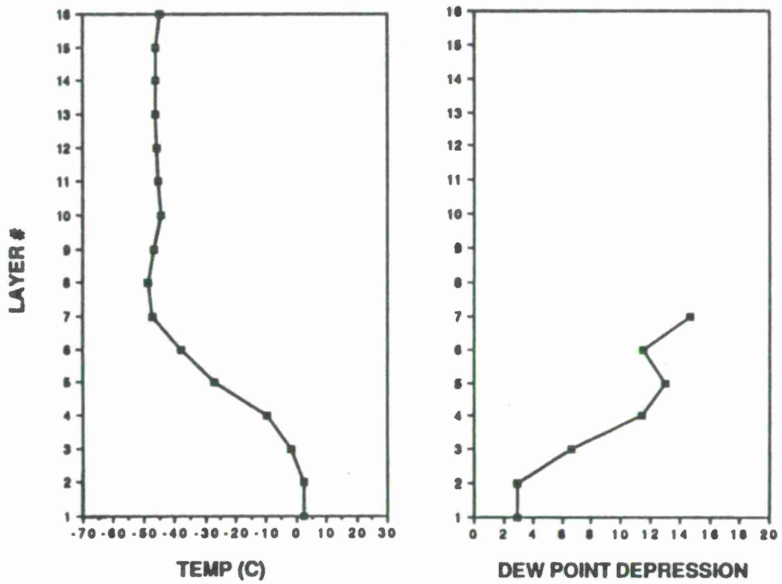
APRIL AT 55.00 N 175.00 E (11)



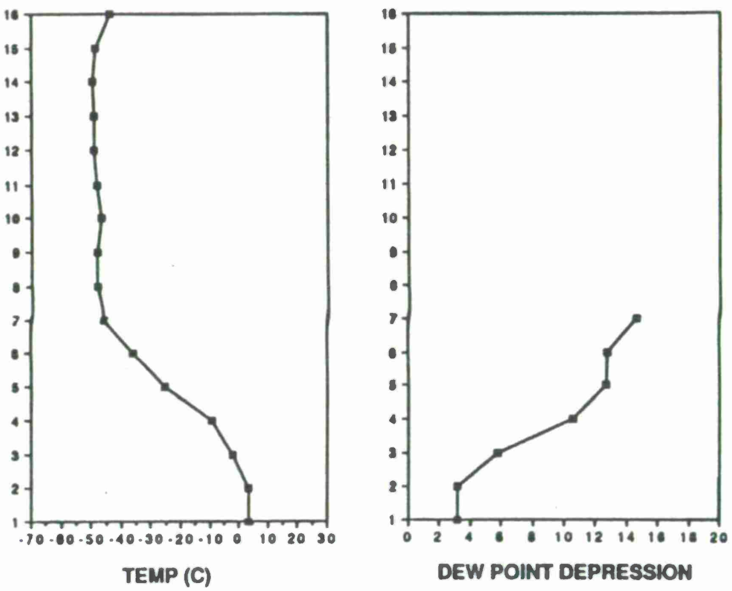


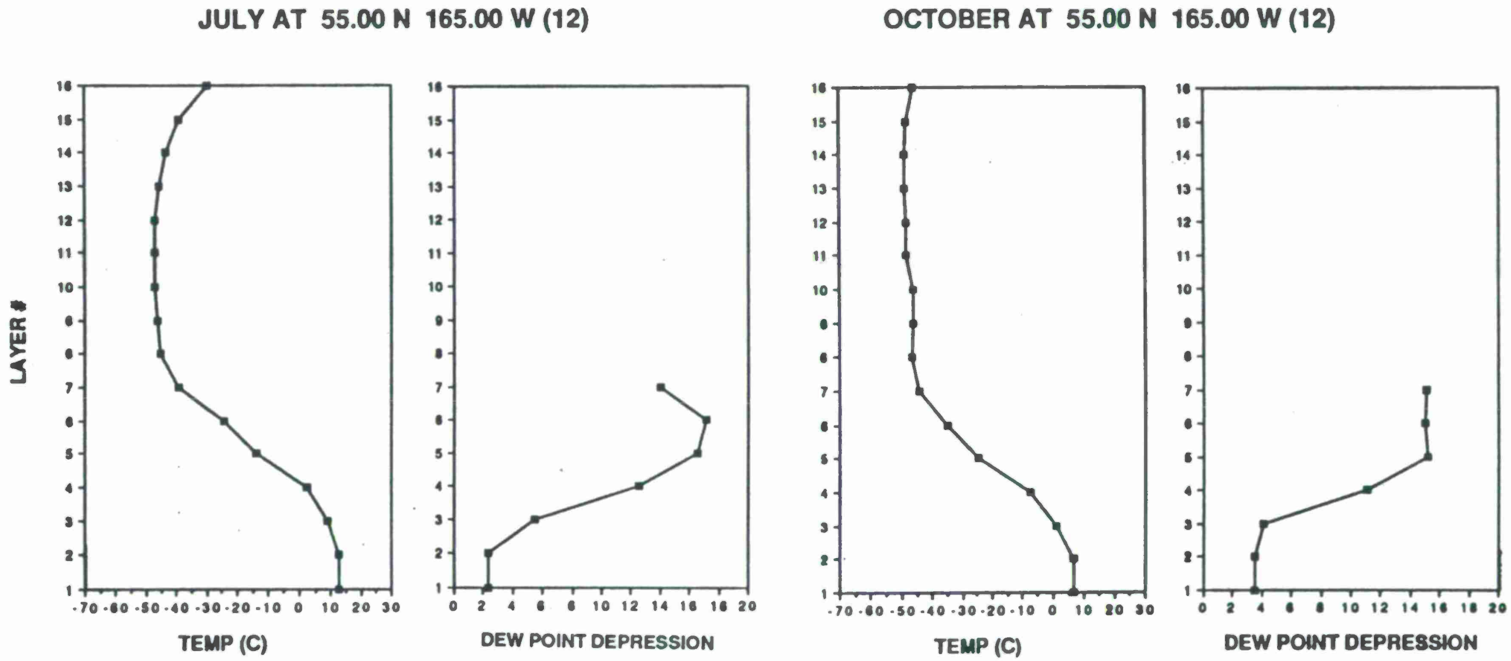
JULY AT 55.00 N 175.00 E (11)
OCTOBER AT 55.00 N 175.00 E (11)
LAYER #
TEMP (C)
DEW POINT DEPRESSION
TEMP (C)
DEW POINT DEPRESSION

JANUARY AT 55.00 N 165.00 W (12)

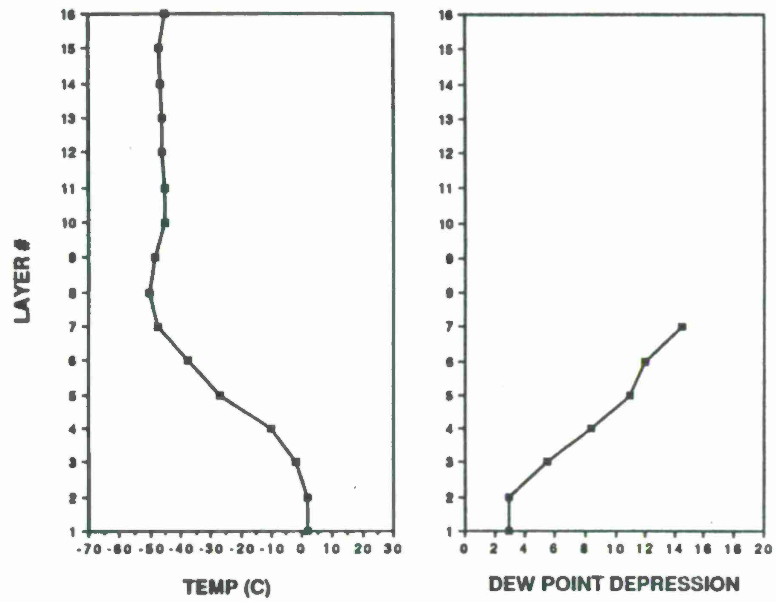


APRIL AT 55.00 N 165.00 W (12)

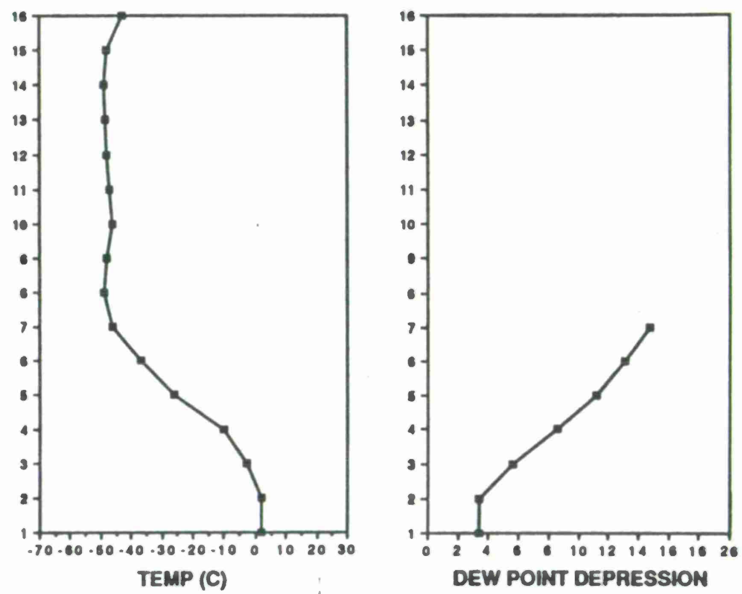



JULY AT 55.00 N 165.00 W (12)
OCTOBER AT 55.00 N 165.00 W (12)
LAYER #
TEMP (C)
DEW POINT DEPRESSION
TEMP (C)
DEW POINT DEPRESSION

JANUARY AT 55.00 N 145.00 E (14)



APRIL AT 55.00 N 145.00 E (14)



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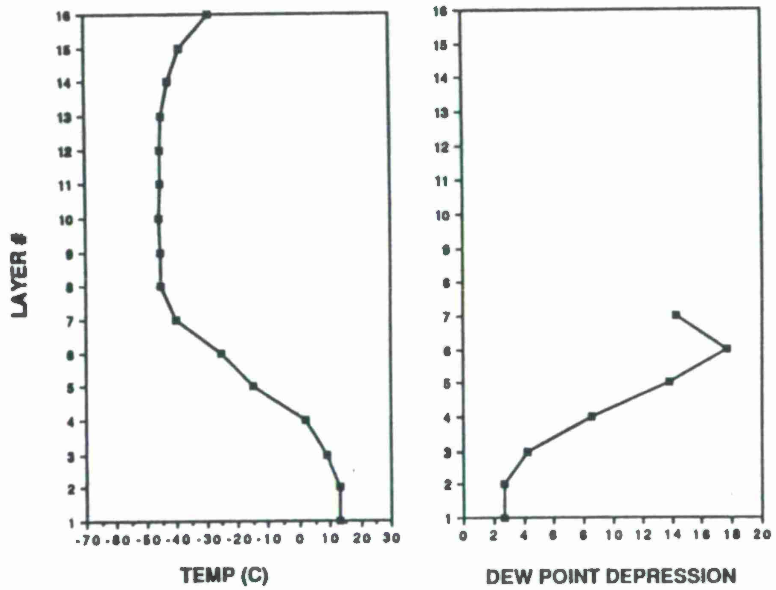

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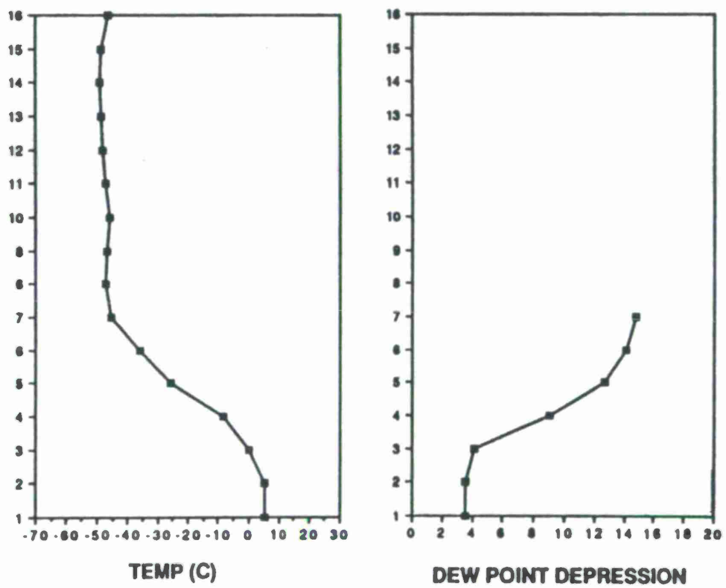

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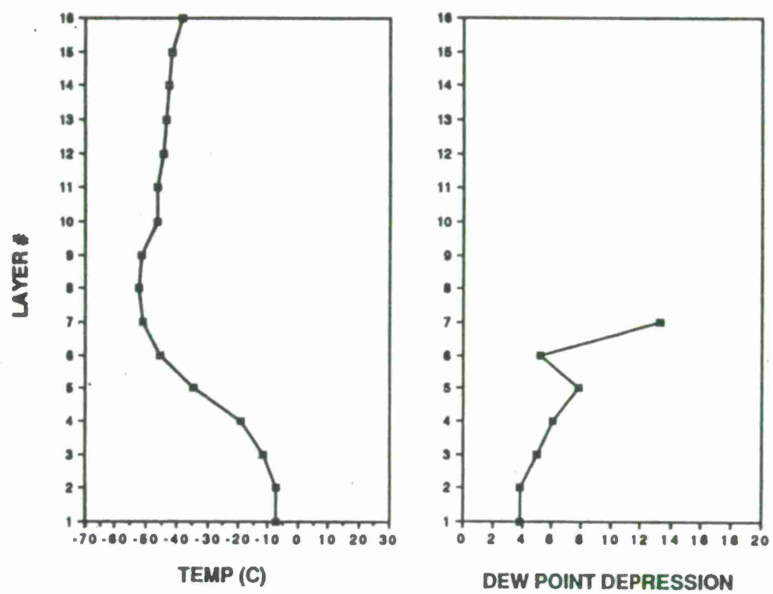

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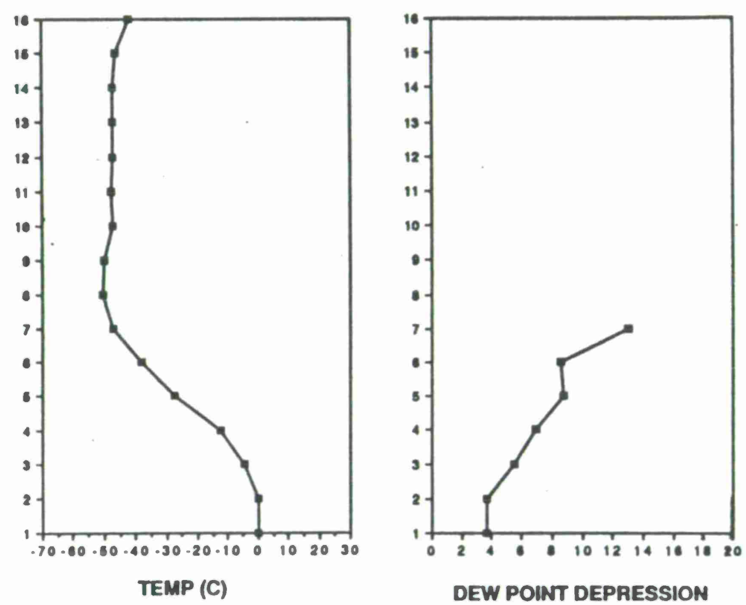

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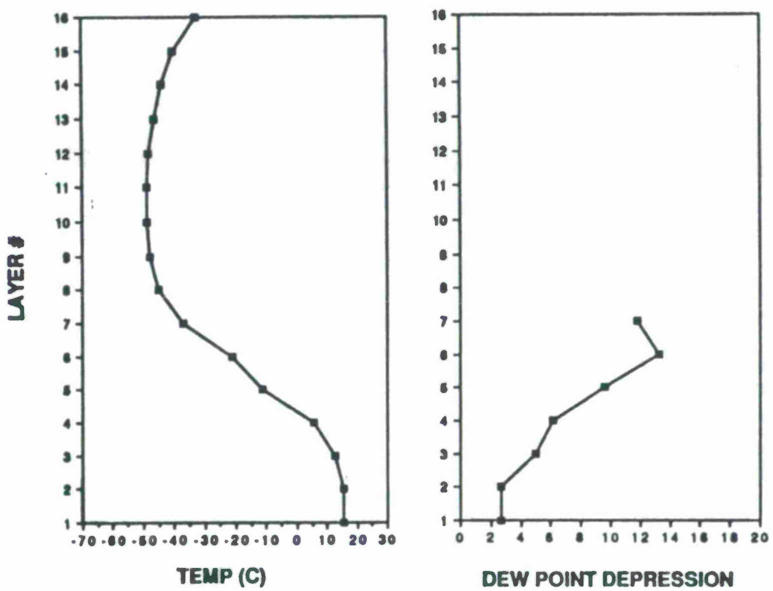

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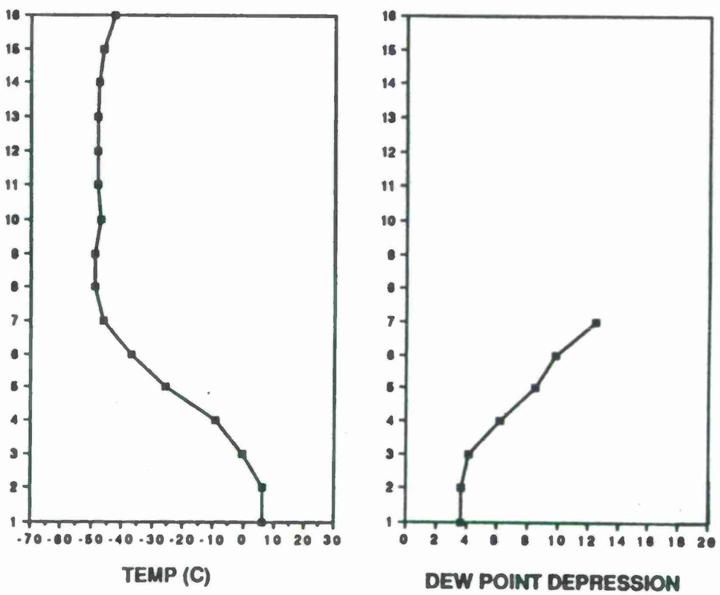

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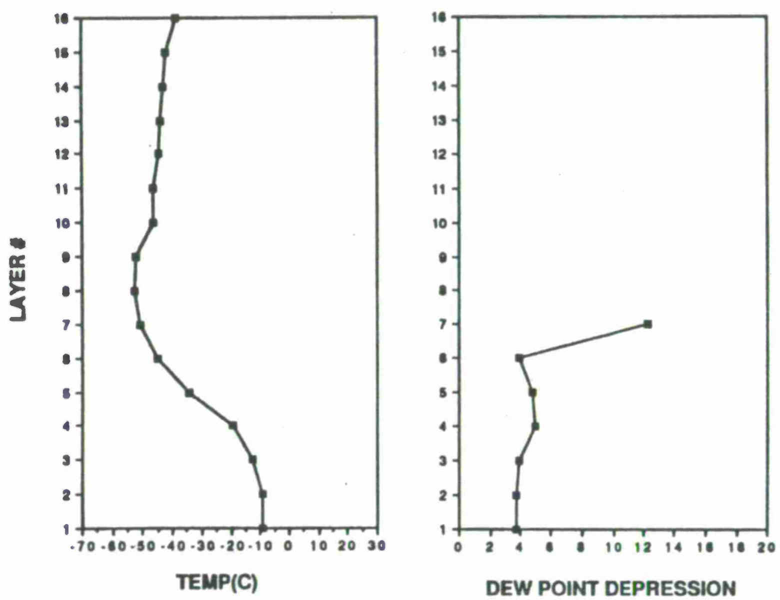

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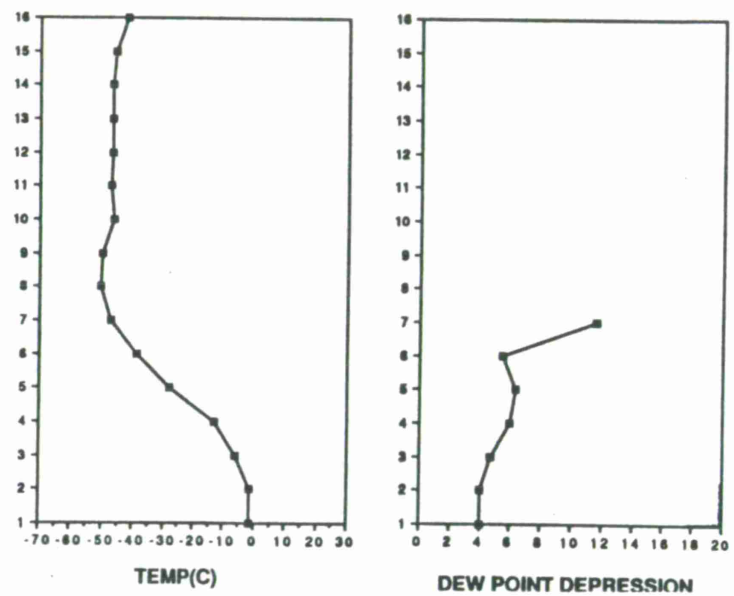

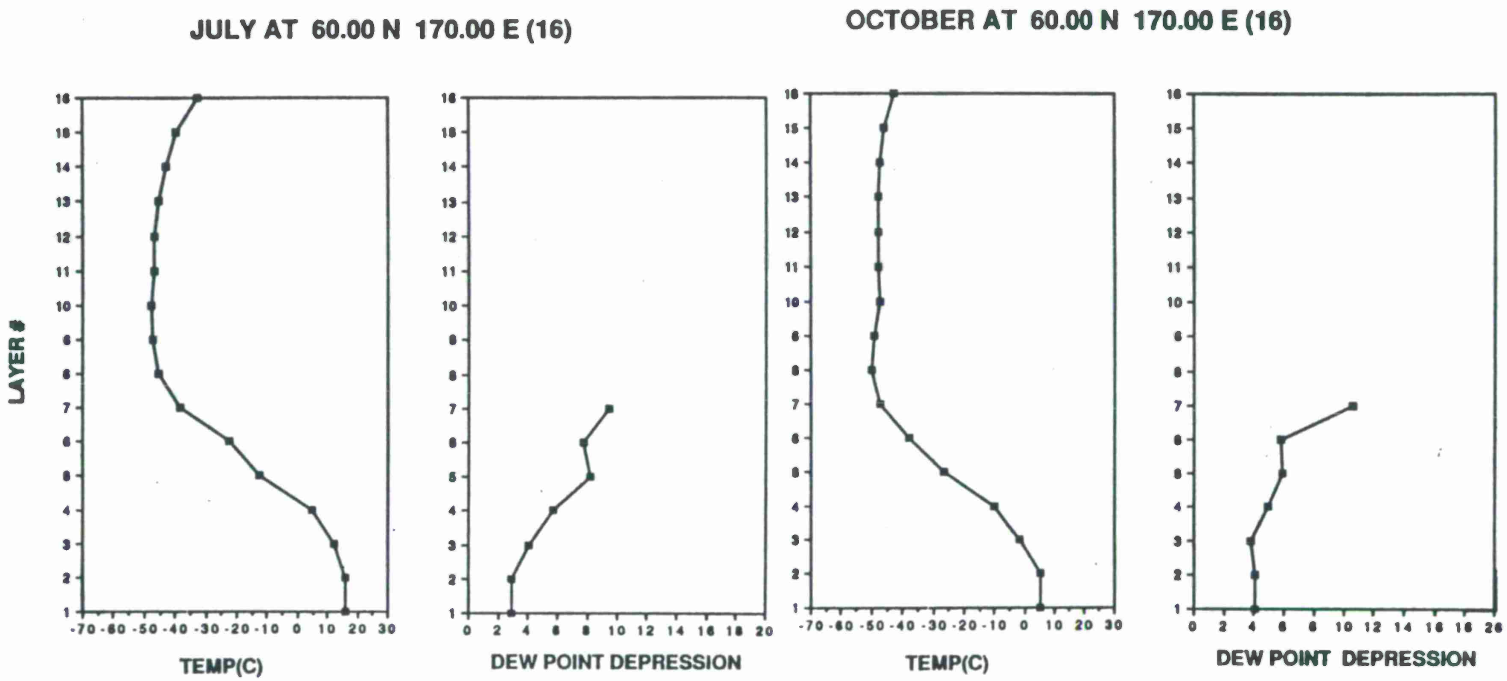
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OCTOBER AT 60.00 N 170.00 E (16)
LAYER #
TEMP(C)
DEW POINT DEPRESSION
TEMP(C)
DEW POINT DEPRESSION

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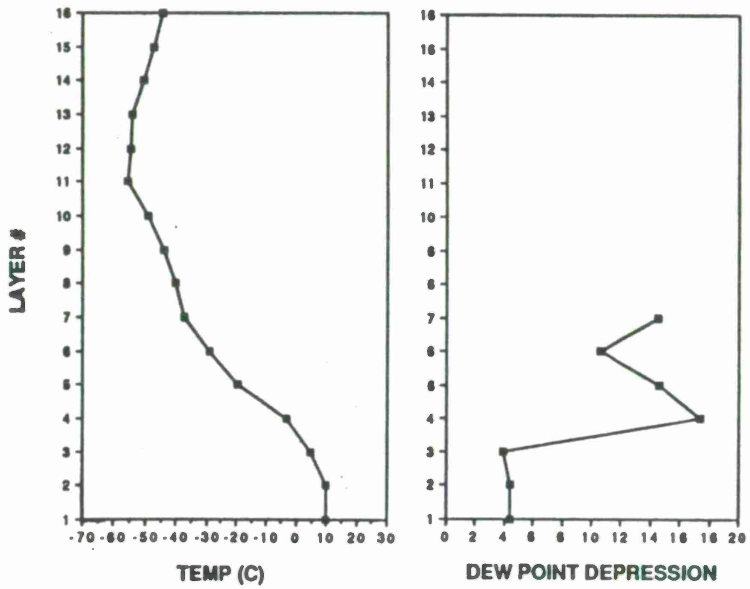

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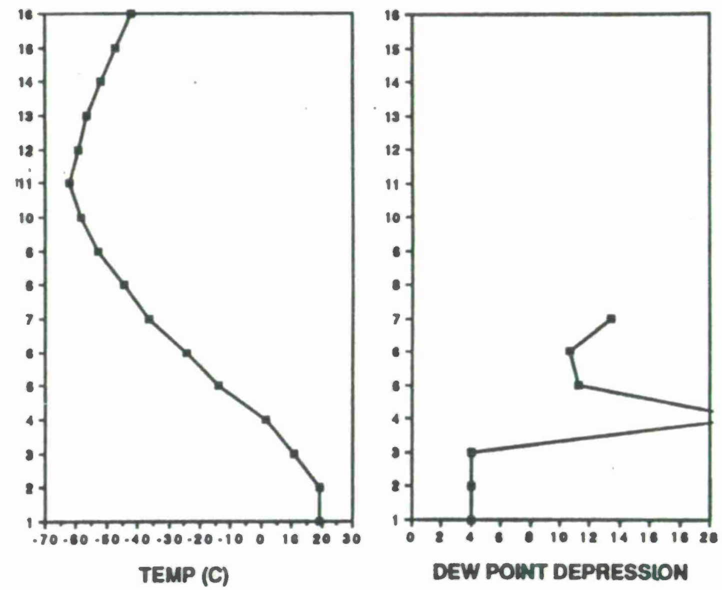

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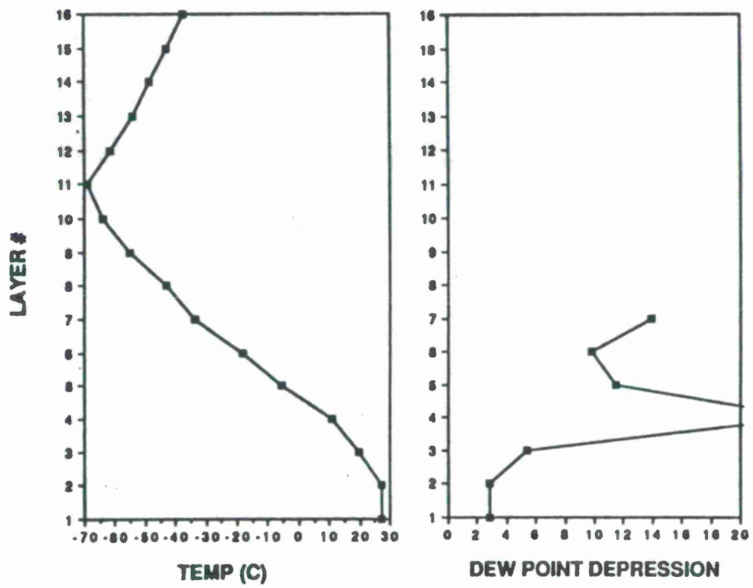

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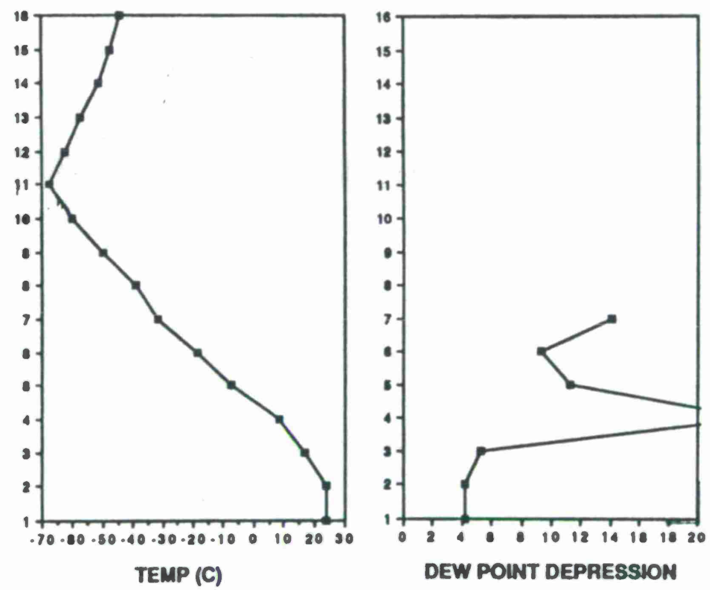

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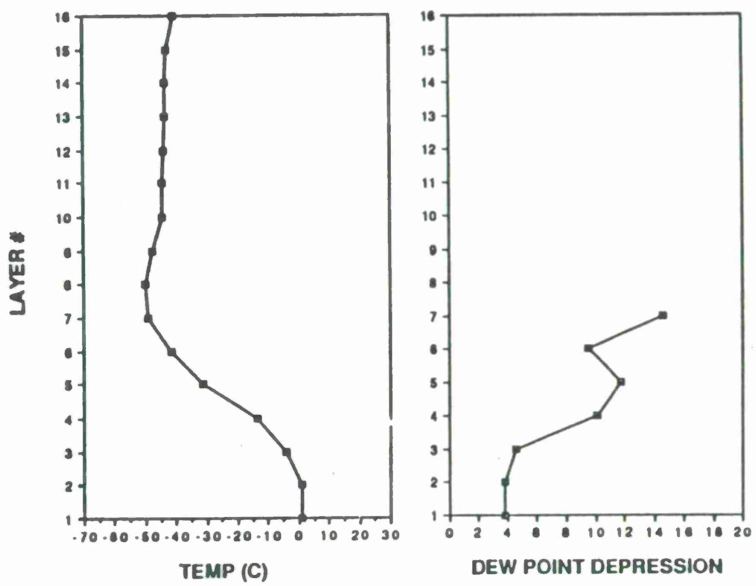

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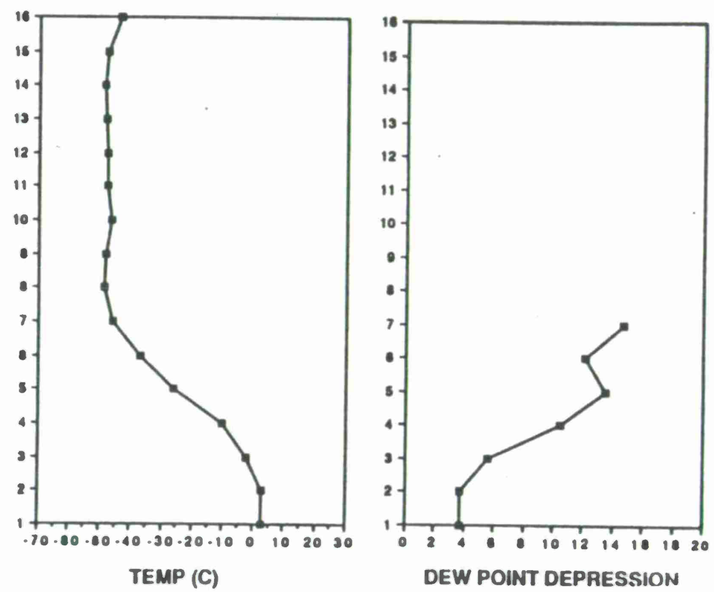

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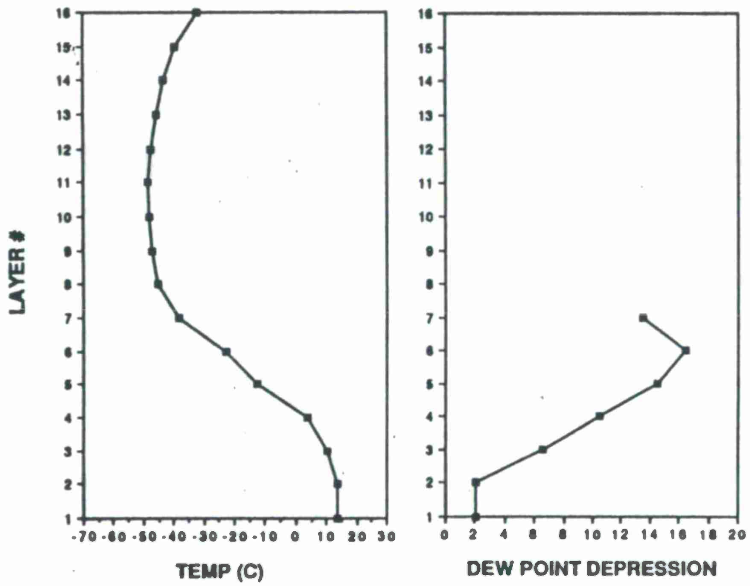

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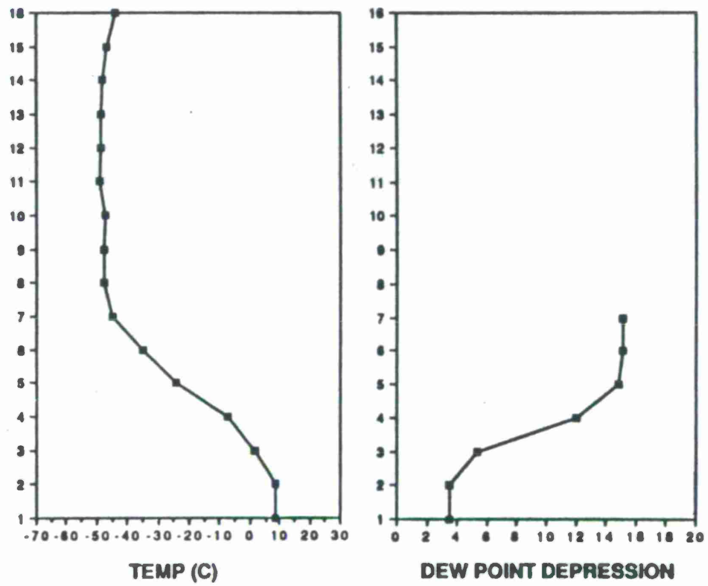

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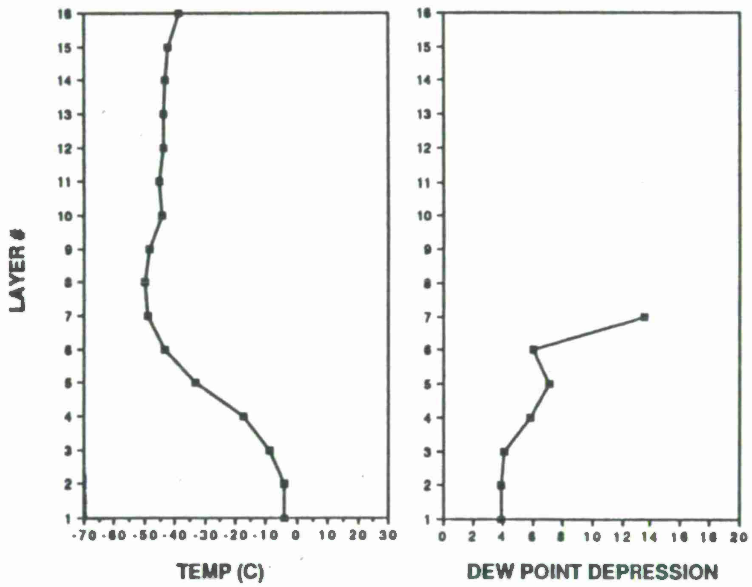

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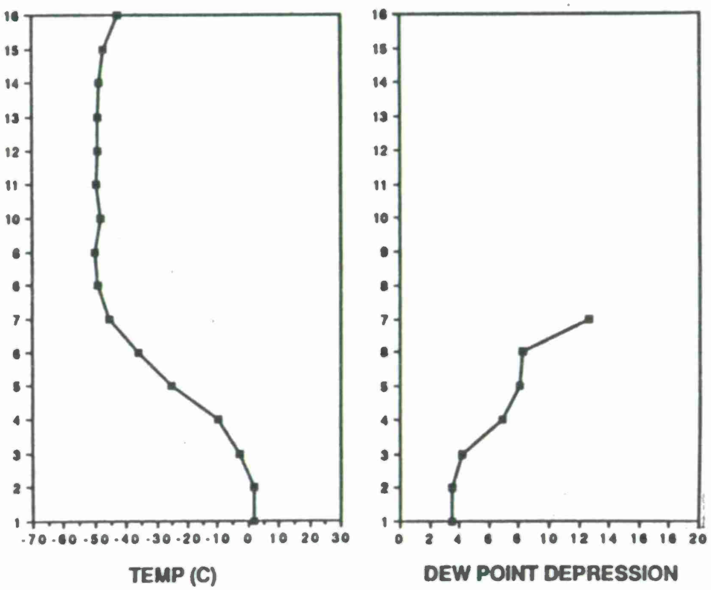

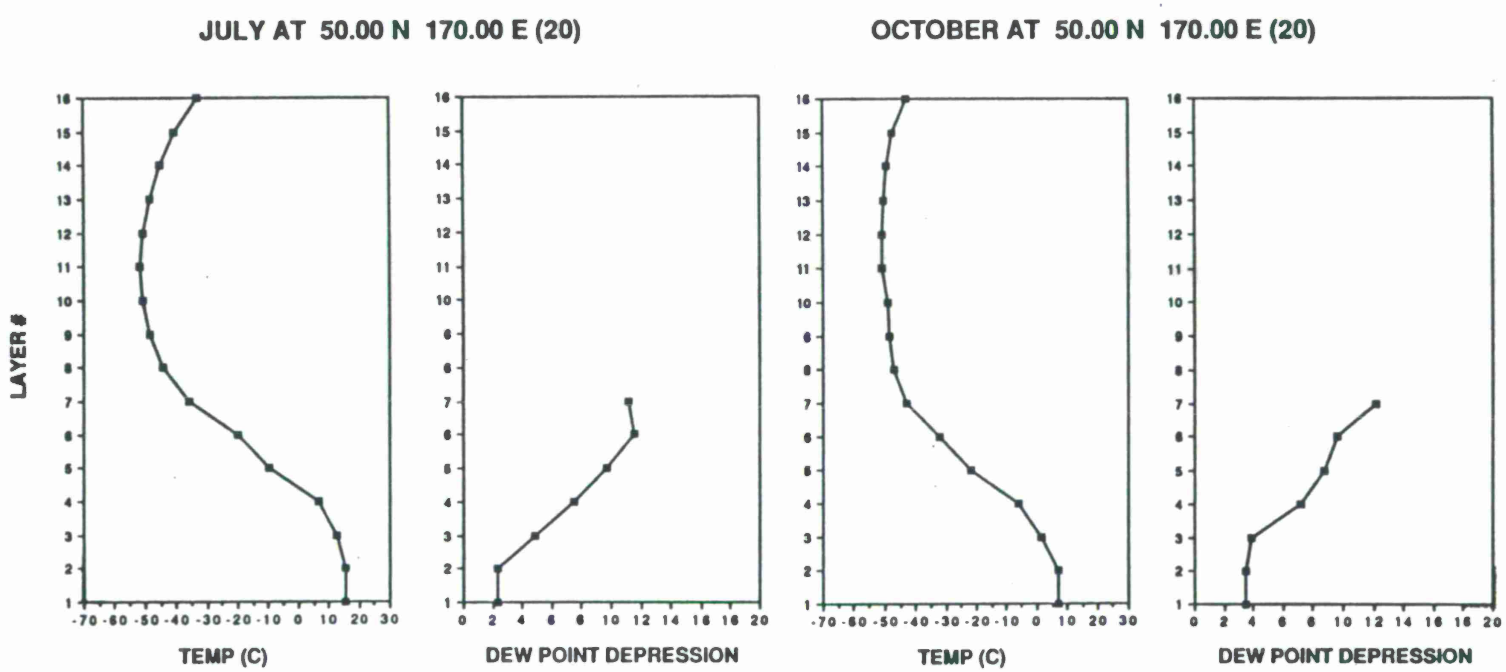

JULY AT 50.00 N 170.00 E (20)
OCTOBER AT 50.00 N 170.00 E (20)
LAYER #
TEMP (C)
DEW POINT DEPRESSION
TEMP (C)
DEW POINT DEPRESSION

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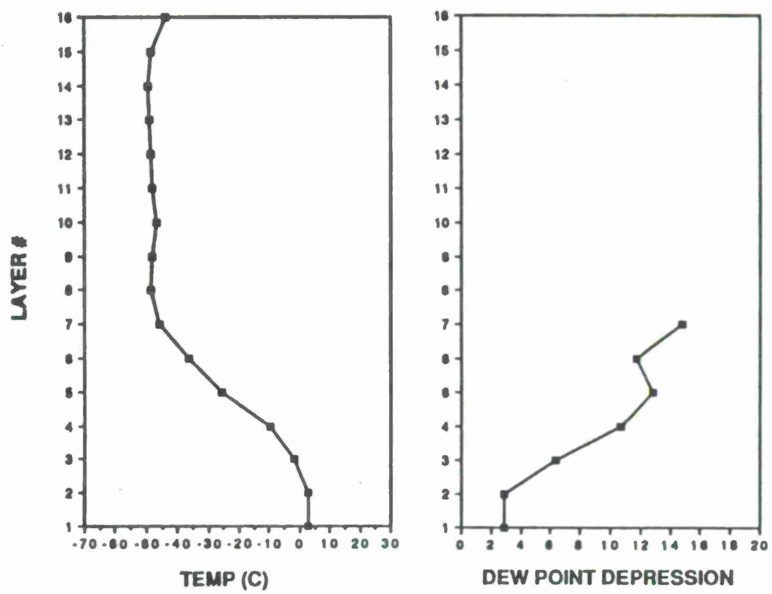

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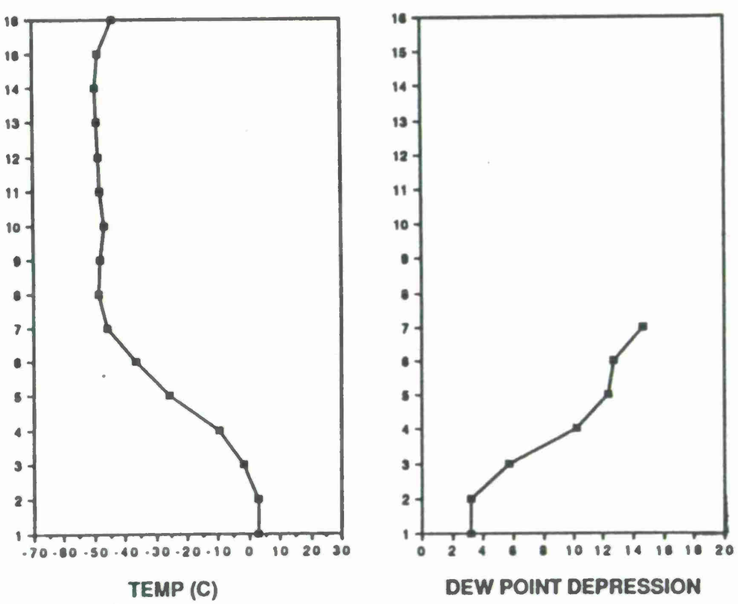

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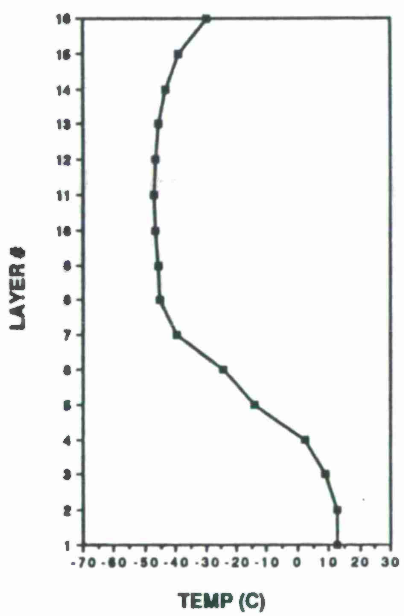

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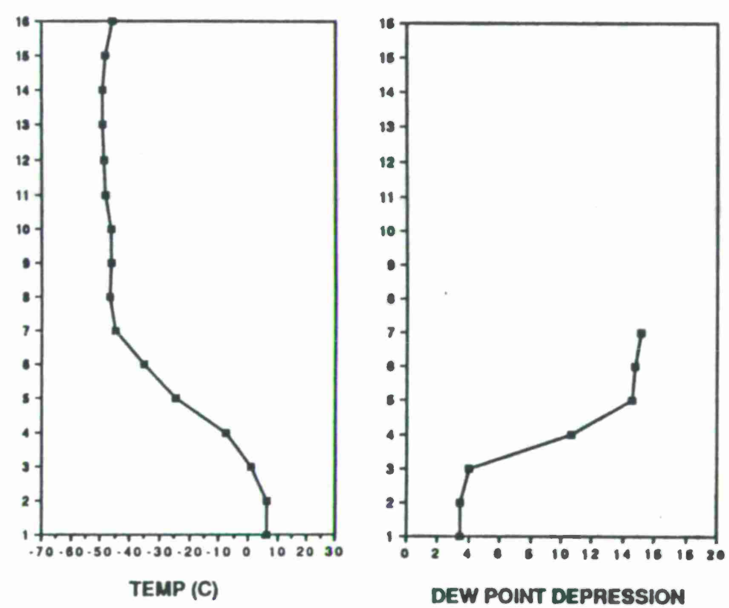

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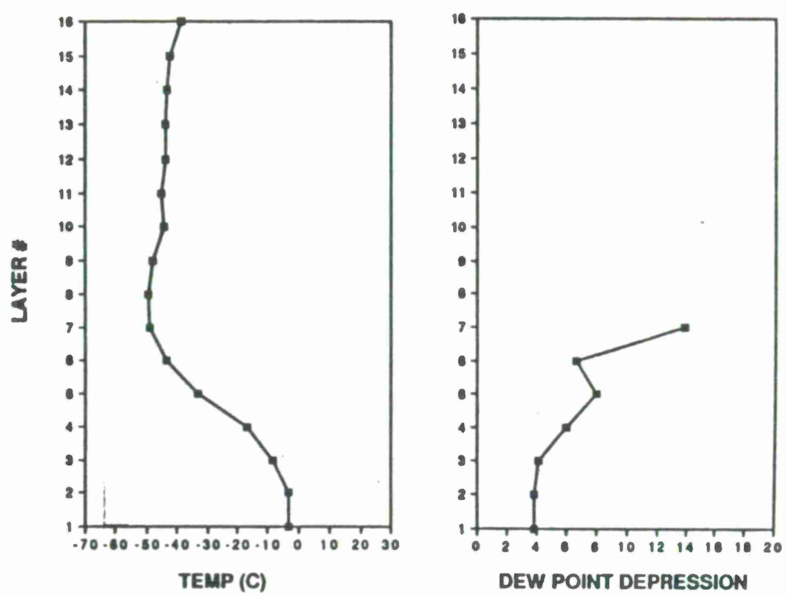

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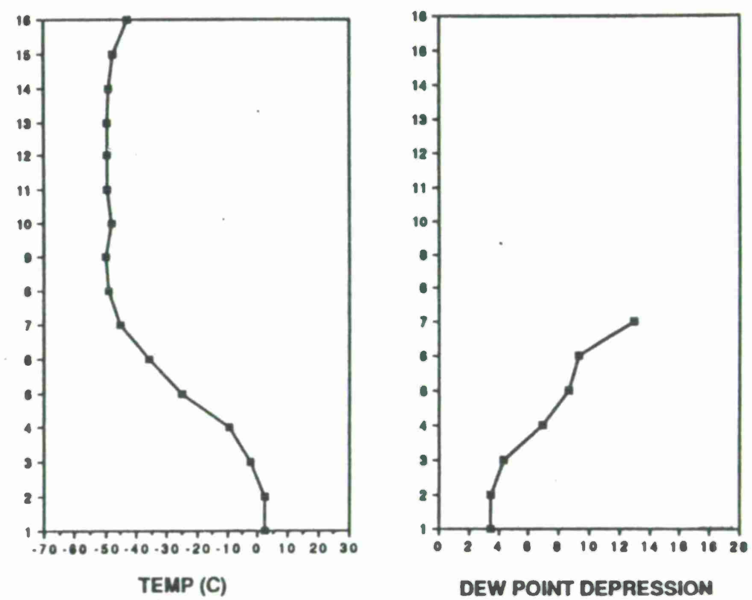

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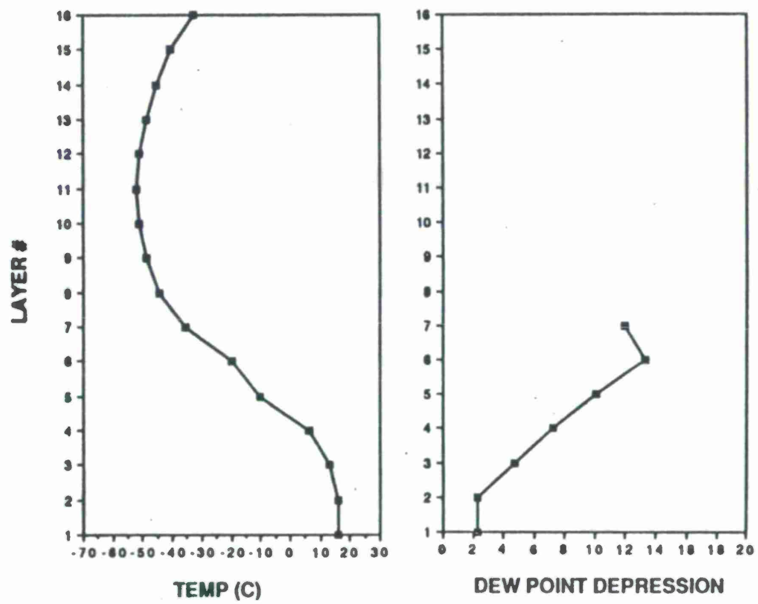

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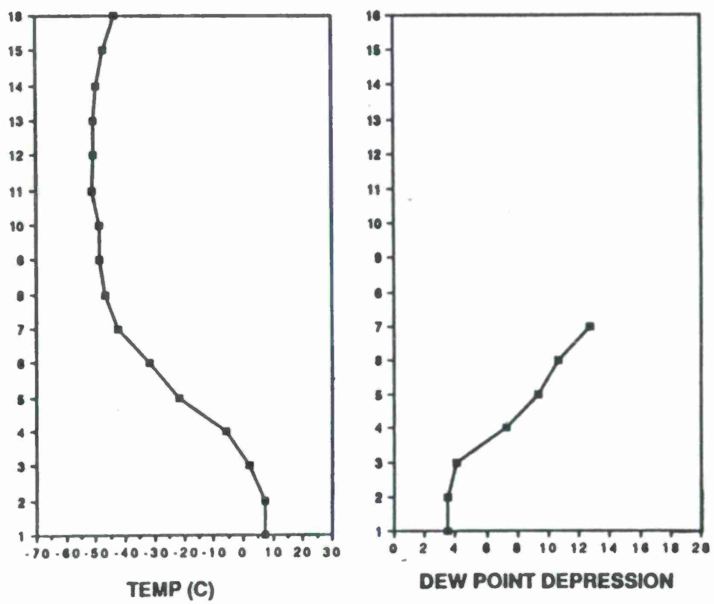

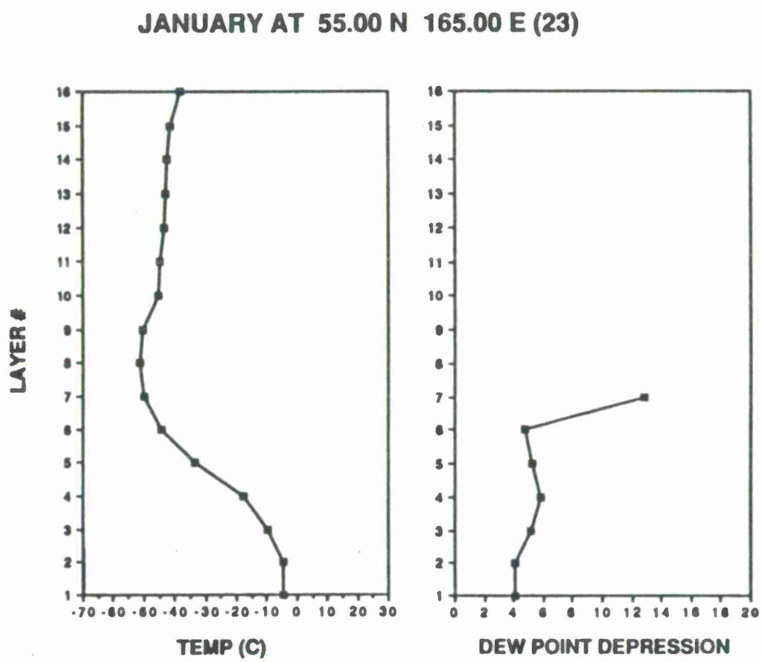
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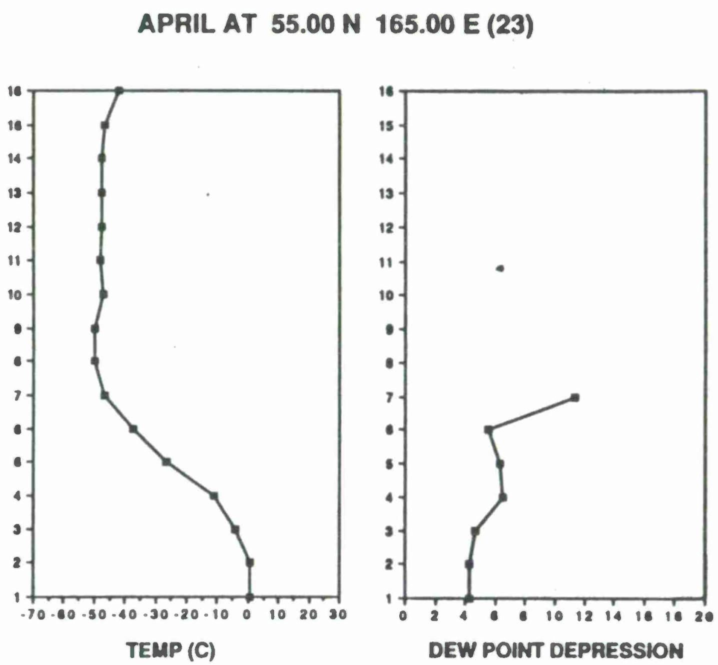
LAYER #
TEMP (C)
DEW POINT DEPRESSION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TEMP (C)
DEW POINT DEPRESSION

108

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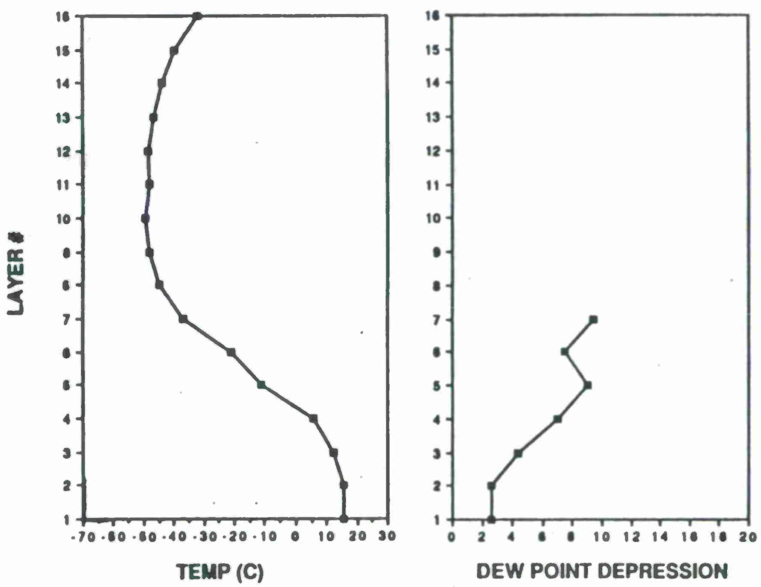

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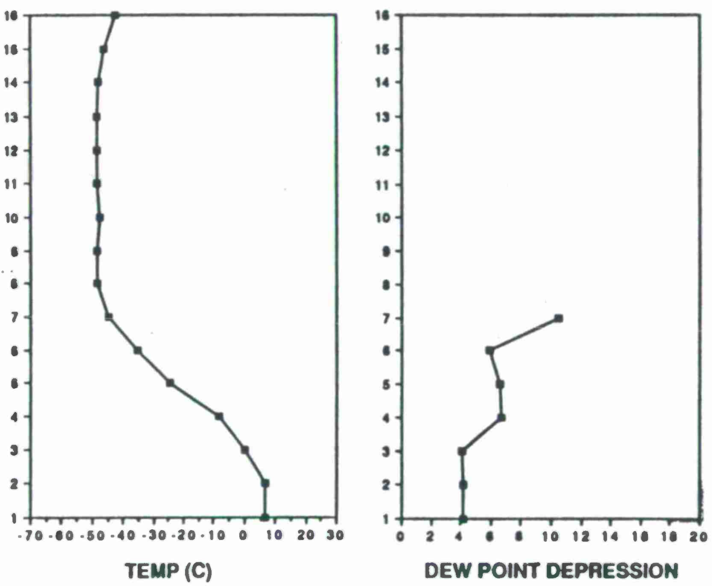

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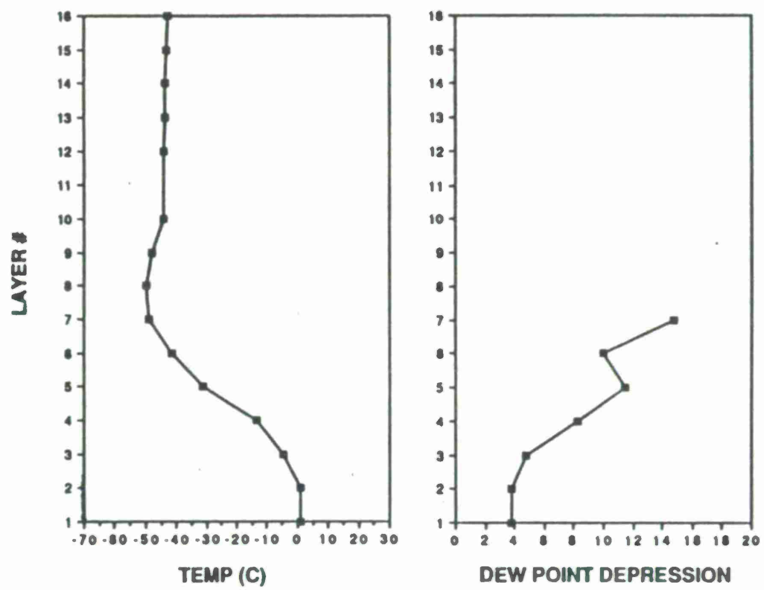

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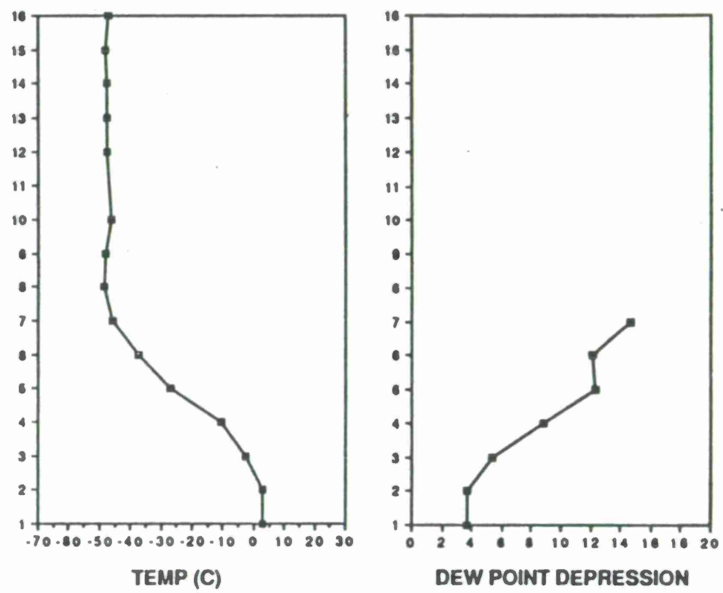

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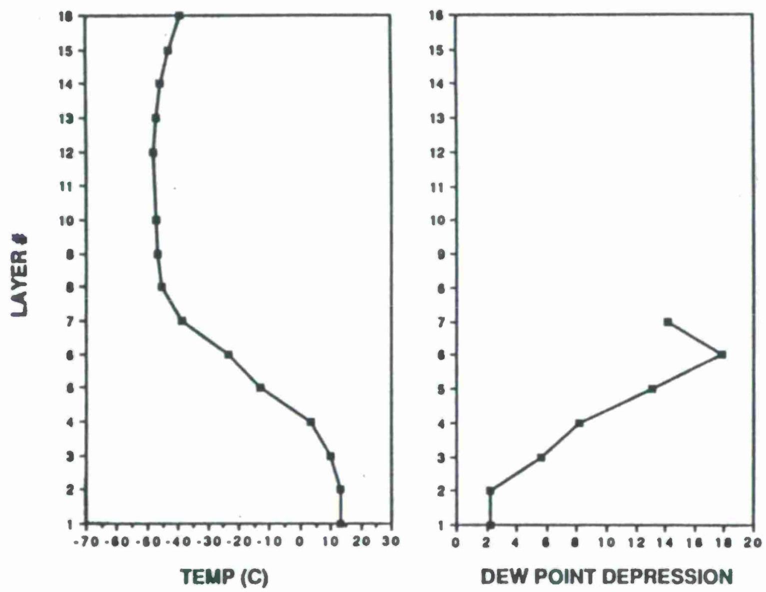

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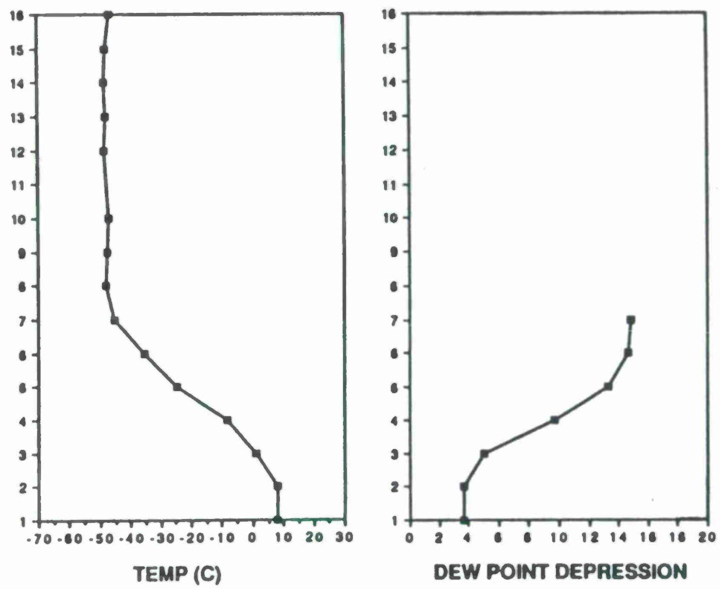

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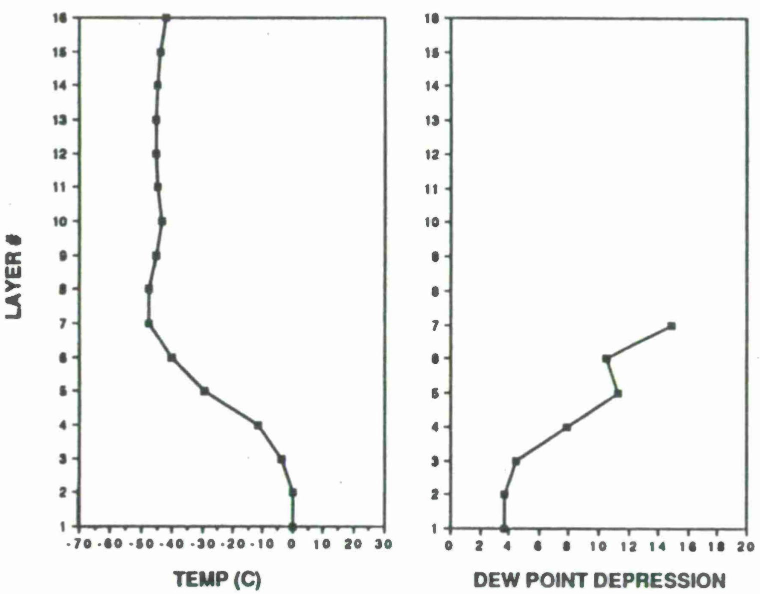

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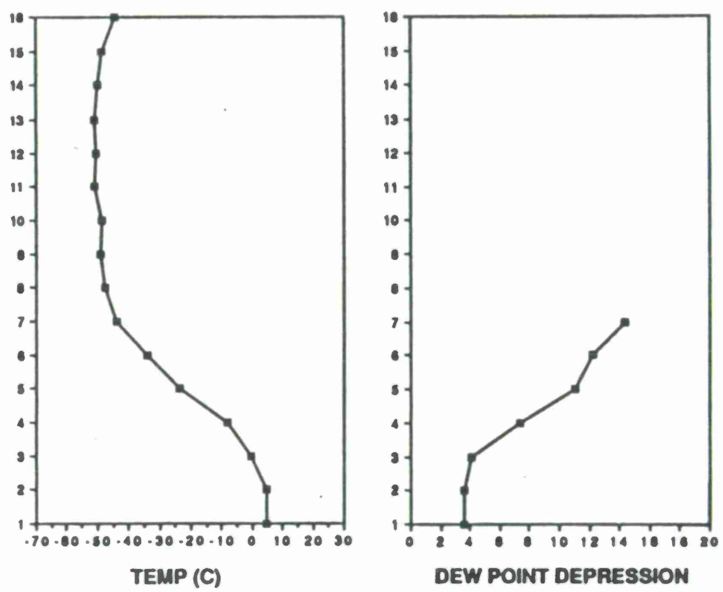

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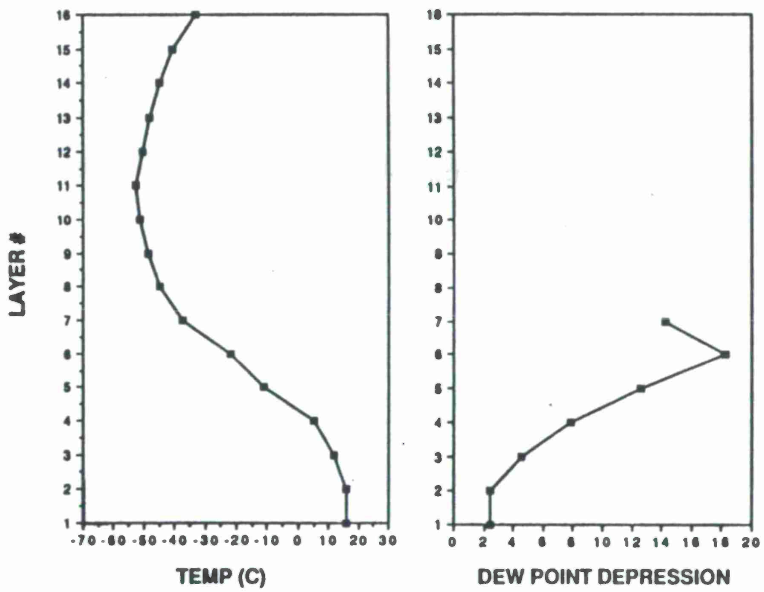

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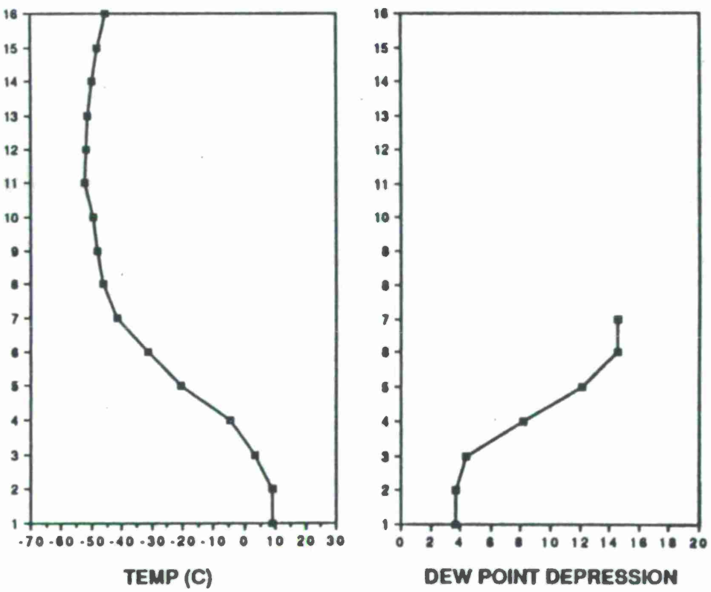

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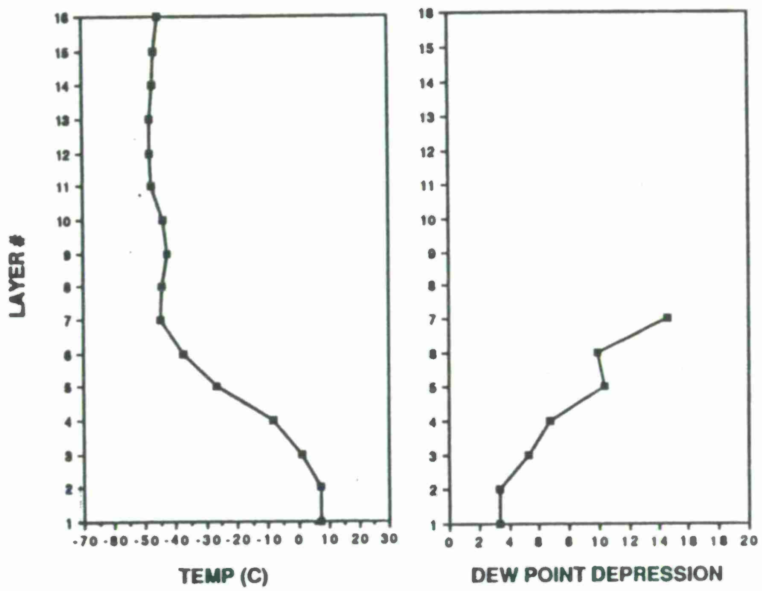

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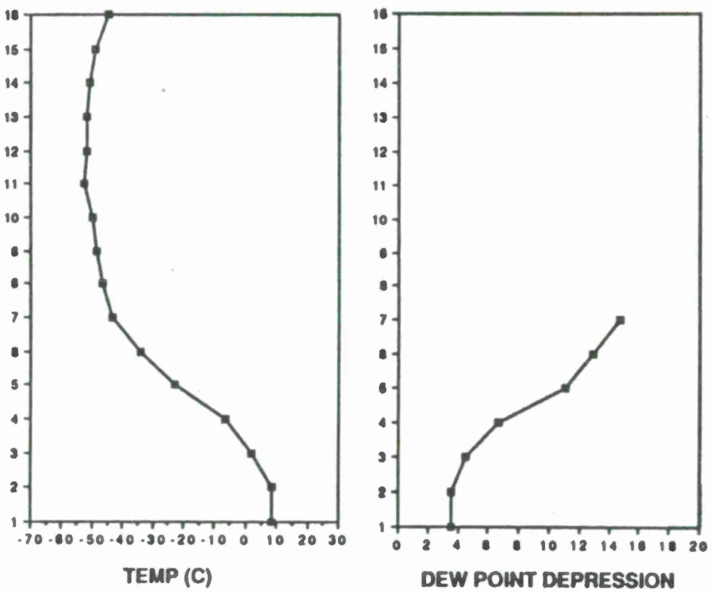

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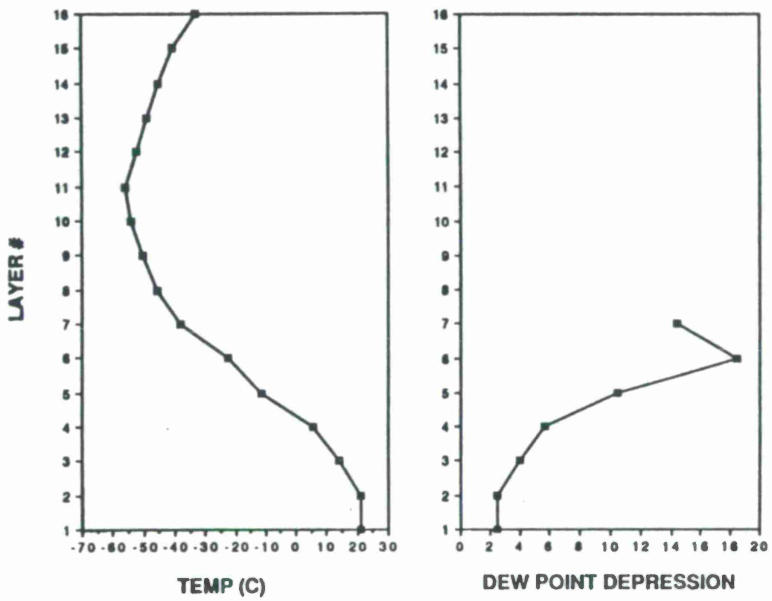

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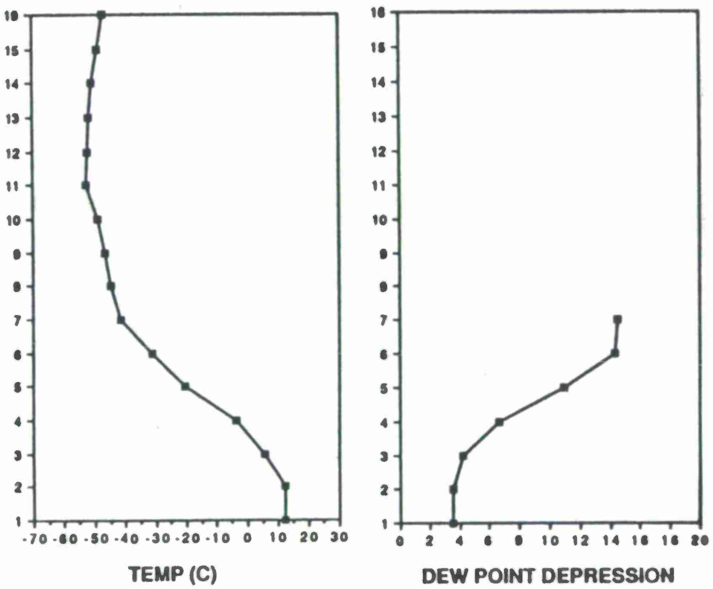

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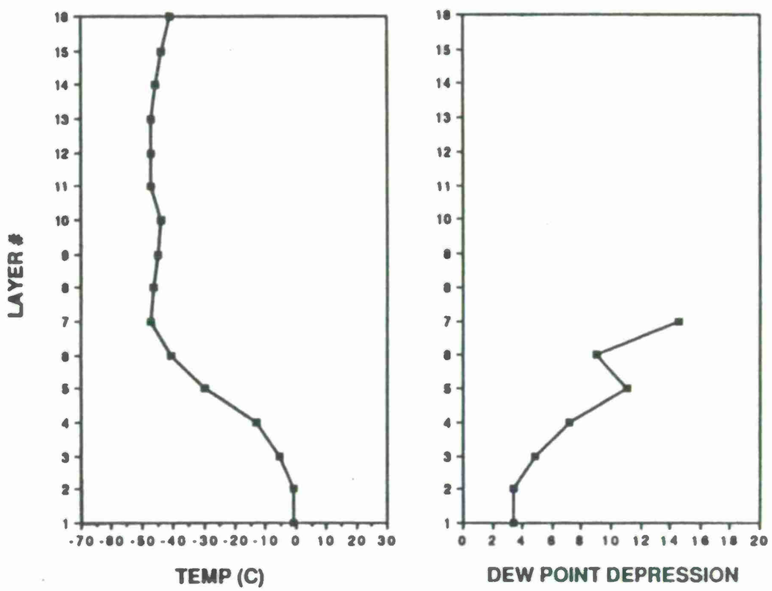

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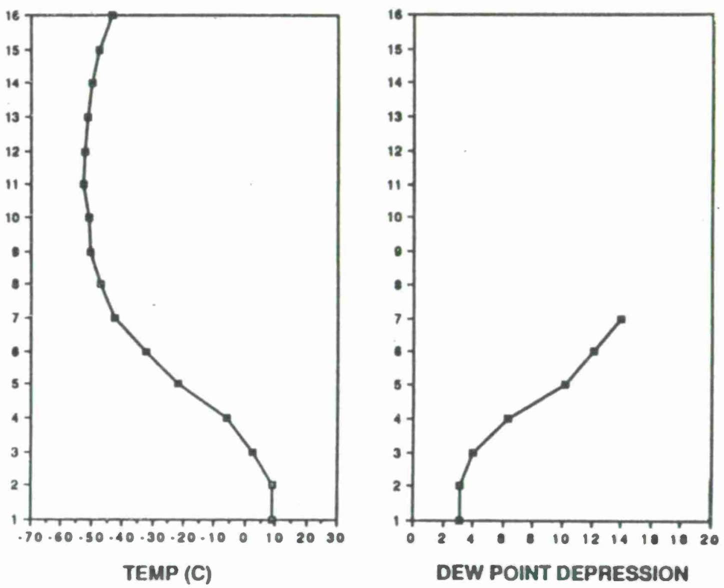

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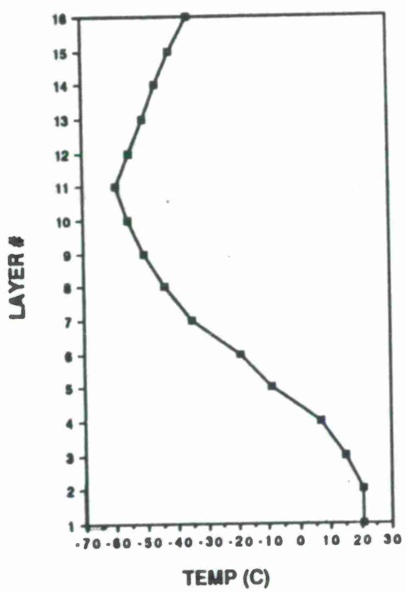

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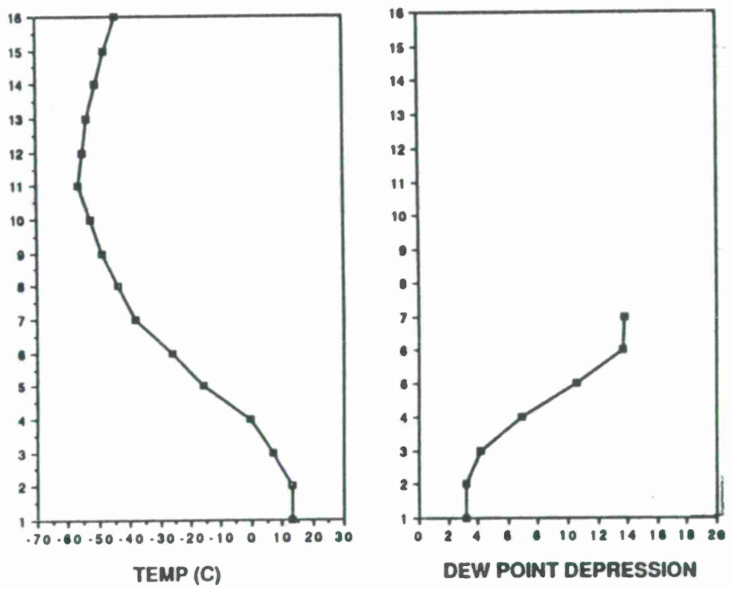

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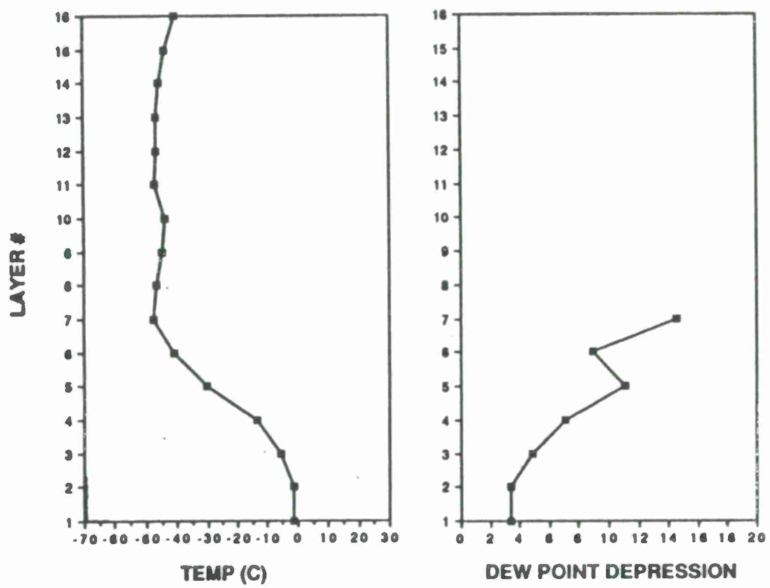

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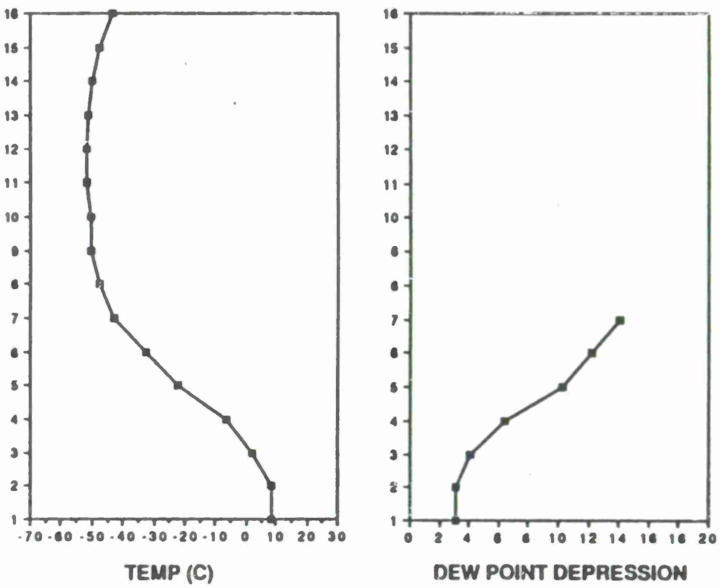

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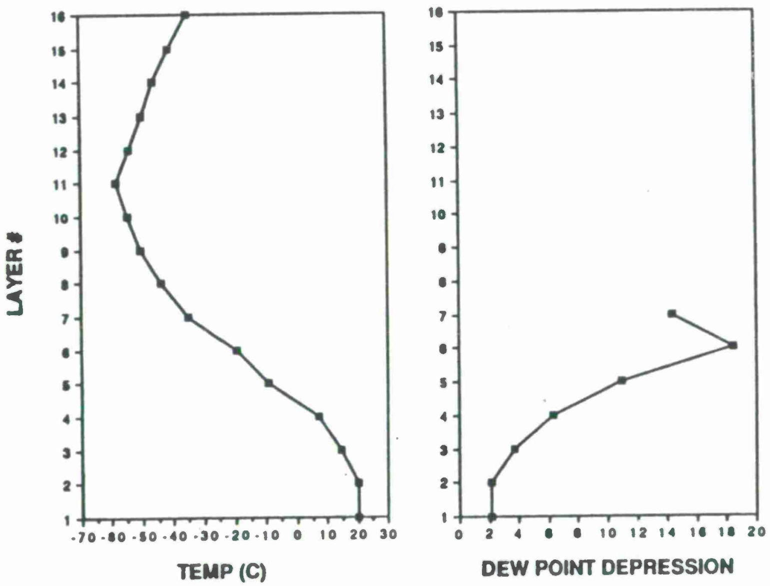

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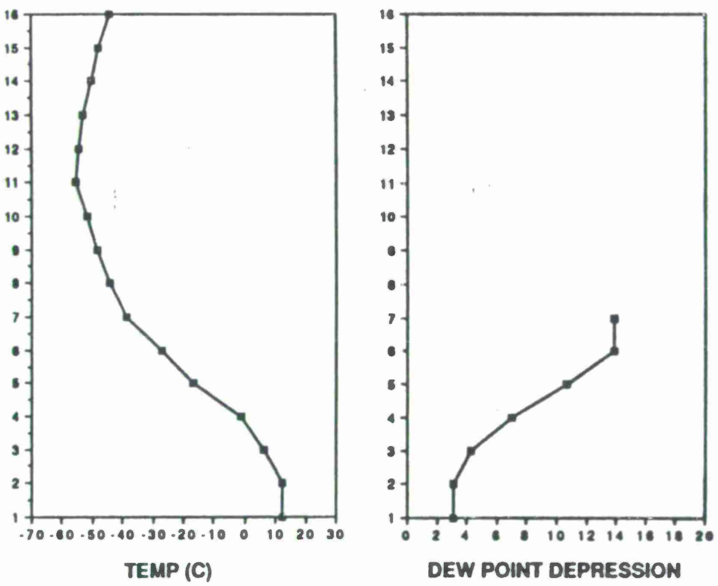

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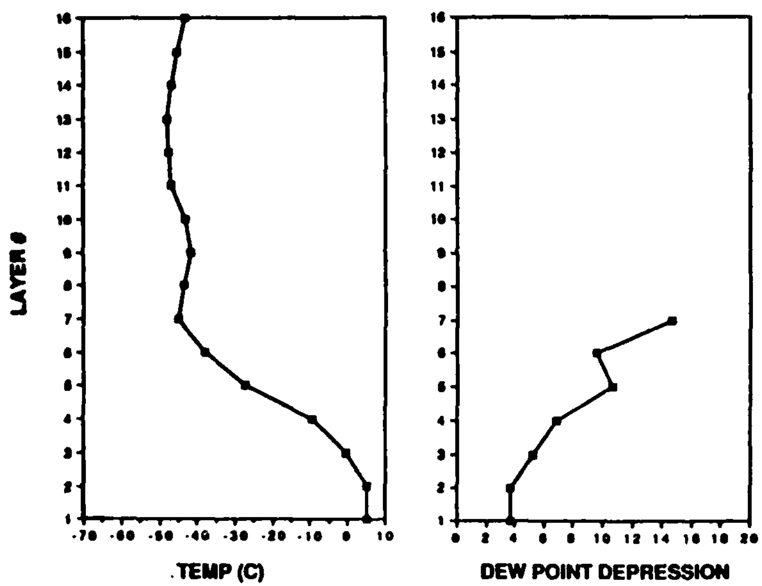

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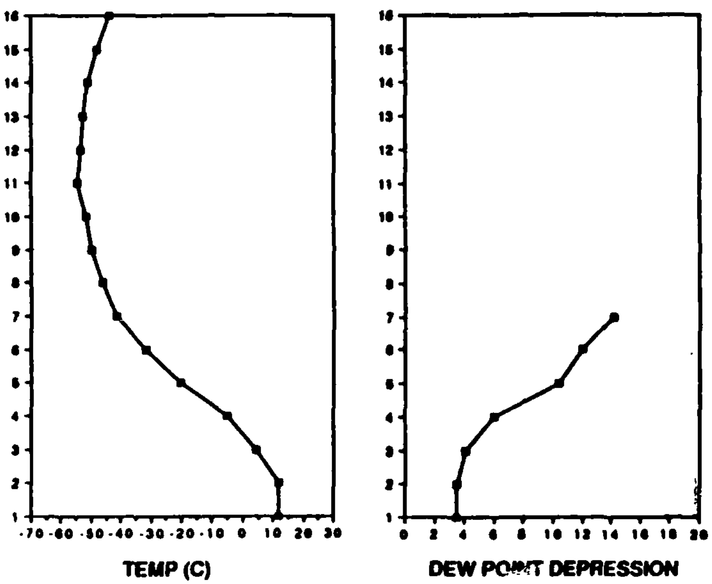

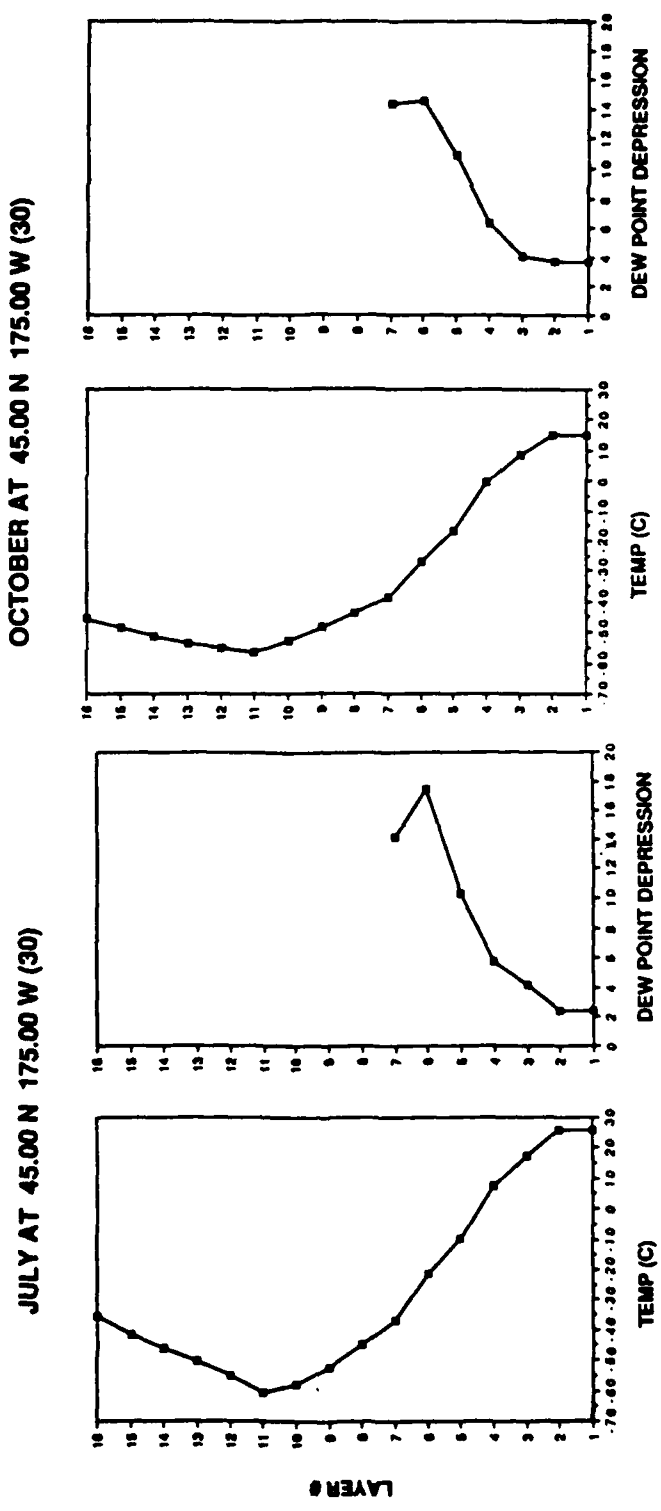
JULY AT 45.00 N 175.00 W (30)
OCTOBER AT 45.00 N 175.00 W (30)
TEMP (C)
DEW POINT DEPRESSION
TEMP (C)
DEW POINT DEPRESSION
LAYER #

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9. L. Stowe, P. Hwang, H.Y. Yeh, and the Nimbus-7 Cloud Data Processing Team, "User's Guide for the Nimbus-7 NCLE and CMATRIX THIR/TOMS Cloud Products," (preliminary draft) NASA Goddard Space Flight Center, Greenbelt, MD (1986).

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13. ABSTRACT *(Maximum 200 words)*

A cloud climatology data set for the North Pacific area is presented based on monthly statistics of mean cloud percent and frequency of occurrence of cloud amount for 18 grid-point locations within approximately 1000 km of Shemya, Alaska. The cloud statistics are derived from the Air Force 3D-Nephanalysis Global Cloud Archive (3D-NEPH Model) for the period 1977 to 1983. These cloud statistics, together with atmospheric temperature profiles derived from the Air Force Summarized Analysis Data Set, are used to determine estimates of cloud top heights and temperatures for representative months at the various locations.

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20. LIMITATION OF ABSTRACT

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